AGRICULTURE

FOR MANITOBA AND THE
NORTH-WEST TERRITORIES

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AGRICULTURE

BY

CHARLES C. JAMES, M.A.

DEPUTY MINISTER OF AGRICULTURE FOR ONTARIO
FORMERLY PROFESSOR OF CHEMISTRY AT THE
ONTARIO AGRICULTURAL COLLEGE

Revised and enlarged for use in the Schools of Manitoba and the North West Territories

BY

A. McINTYRE

ASSISTANT PRINCIPAL, NORMAL SCHOOL, WINNIPEG

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PREFACE.

The purpose of this book is to aid the reader and student in acquiring a knowledge of the *science* of agriculture as distinct from the *art* of agriculture; that is, a knowledge of the "why," rather than a knowledge of the "how." The science of agriculture may be said to consist of a mingling of chemistry, geology, botany, entomology, physiology, bacteriology, and other sciences, in as far as they have a bearing upon agriculture. The aim has been to include but the first principles of these sciences, and to show their application to the art of agriculture. In a field so wide, and with so limited a space at the author's disposal, this work claims to deal only with the simple first principles of agricultural science. It is hoped, however, that the beginning here made will lead to a further study of what is one of the most interesting, and most profitable sciences—one that is at the present time making most wonderful advance.

From his experience of several years' teaching at the Ontario Agricultural College the author believes that the rational teaching of agriculture in Public and High Schools is not only possible, but would be exceedingly profitable. An intelligent understanding of the science underlying the art of agriculture will add much interest to what is otherwise hard work, and, as a natural consequence, the pleasure of such work may be greatly increased. The agriculturists of this country in the future will work at a serious disadvantage if they do not have some knowledge of a very interesting science that underlies their work. The residents

of our towns and cities also will find that some knowledge of the science of agriculture may be of use to them, and may increase the respect and consideration for the calling that contributes so largely to the general wealth and welfare of this country.

To the many who have offered help and advice and to all who have in any way contributed to this work, sincere thanks are offered.

The First Principles of Agriculture, by Dr. James Mills and Prof. Shaw will be found useful for reference, as some of the subjects herein dealt with are enlarged upon in that work.

C. C. JAMES.

PREFACE TO THE MANITOBA AND NORTH-WEST EDITION.

The value of this text is enhanced materially by the addition of a chapter on the Science of Every-day Life. Such work is invaluable as a groundwork for the subsequent study of Physics and Chemistry. It also makes plain the reason for the various methods pursued in scientific farming. It introduces the student to the life about him so that he may learn to respect material things and find in them not only facts useful in application to practical life but also gratifying to the intellect. The experiments selected form a series. Each has a purpose in view, and all may be successfully worked by using very common apparatus.

If wisely followed this chapter should prove a delight to the student and should reveal something of the handiwork and thoughts of Him—"Who in creation acts His own conceptions."

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"*Agriculture is the oldest of the arts and the most recent of the sciences.*"

"*Perfect agriculture is the true foundation of trade and industry—it is the foundation of the riches of States.*"

PART I.

CHAPTER I.

THE SEED.

THE FORMING OF SEED.—We scatter some oat-grains over the earth and then lightly cover them with the fine surface soil. The spring rain falls, and the air grows warmer. In a few days the green blades of the oat plants appear through the soil all over the field. If we pull up some of these green shoots we find that each one grows from a single seed, and each plant has a bunch of small hairy roots. If we look closely we may find the old husk, or the covering, of the grain that we planted, but nothing more. What was once a seed has now become a plant with roots in the soil and stalk and leaf above the soil. Perhaps we may find some seeds that were buried too deeply and that have not sprouted. On through the summer the oat plants grow, tall and green; soon the head branches out and blossoms; then the grain forms, first soft, soon becoming harder, and the plants lose their green color and turn brown and yellow. We cut down the plants and later on thresh them out, separating the grain from the straw. The roots or stubble left behind in the soil decay; they will not grow again. The straw also will not grow; it is fed to the stock or used as litter. But the grain we may feed to the stock or we may use it again for growing another crop of oats next year. We began with the seed and the plant has given us seed again, just like the seed with which we started. The seed, then, is the beginning and the end of the oat plant, whose aim in growing appears to be to form seed that will produce other plants like itself. The

seed appears to be the most important part of this plant; its life passes on through the seed. We therefore begin our study of plants with the seed.

Many other plants of the field, like the oat, sprout, grow, form seed and die in one season (Annuals). Some others, such as carrots and turnips, do not form seed unless left in the ground for a second season (Biennials). Then their roots and stalks die. There are others, such as fruit trees, nut-bearing trees, grape vines, that form seed year by year, but still keep on living (Perennials).

Make a list of the plants of the farm and garden under these three classes: Annuals, Biennials and Perennials.

Shape and Size of Seeds.—The seeds of the same kind of plants are very much alike in shape and size, but the seeds of oats, wheat, barley, corn, peas, beans, turnips, pumpkins, apples, red clover, and timothy all differ. So do the seeds of the grasses and of the weeds. Some are ball-shaped like peas, some are long and pointed like oats, some are flat like pumpkins, some are three-sided like buckwheat and beech nuts. And there are many other forms; in fact, there is a different form for every different kind of seed.

One seed may send up two or more stalks, but one stalk never grows from more than one seed. Find out how many grains of wheat there are on a single stalk; how many seeds there are on a dandelion head, and how many grains of corn will be grown from one seed of corn.

Get a number of small glass bottles about two inches long. Collect the seeds of grains, of grasses, and of weeds. In the summer and fall gather these seeds from the growing plants, in the winter get them from the bins. Put these separately in the bottles, write the name of each kind on a piece of paper and fasten it on the bottle. You can in time get a collection of all the principal seeds that are to be found growing in your locality, and you can then study them. After a while you can write on each its botanical name also.

The Structure of the Seed.—Wheat and oats are too small for us to take apart easily. Let us take a large seed such as a hickory nut. First the rough outer husk is taken off, then we

come to the hard shell. If we crack this carefully we can take out "the meat" in one piece. We see that it is made up of two parts, joined together at one end. Notice at which end of the shell the two parts are joined together.

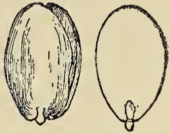


Fig. 1.—An Almond showing parts just separating; also half of same showing tip that will grow downward into root and upward into stem.

Now take another nut—an almond. We crack it; the meat comes out in one compact piece. We place this in water for a couple of minutes and then we carefully rub off the coating. We find that the white almond will separate into two parts that are joined together at one end, very much as in the hickory nut. We find also that there is a tiny tip between these two parts. The nut appears to be made up of two thick leaves joined to a very short stem. It is somewhat like a plant with a short stalk, having two big leaves, but no roots.

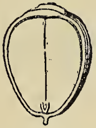


Fig. 2.—An Acorn cut in two.

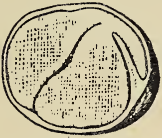


Fig. 3.—A Horse-Chestnut cut in two showing seed leaves and tip.

Fig. 4.—An Apple-Seed.

Fig. 5.—A Pumpkin-Seed.

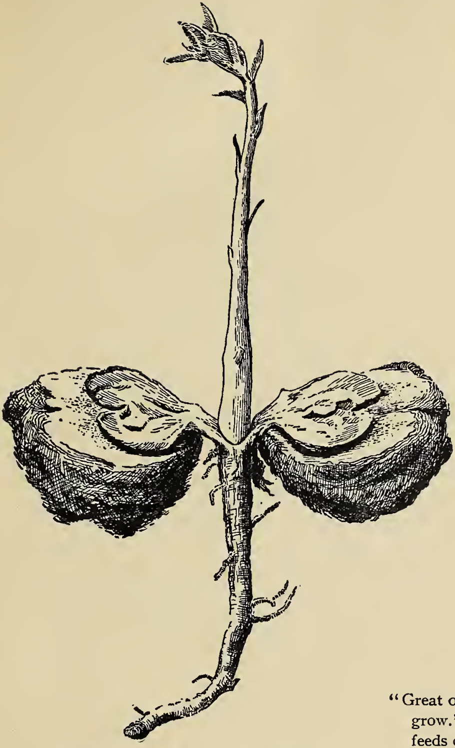
We can examine the seeds of the acorn, the horse-chestnut, the apple, the pea, the bean, and the pumpkin, and we find them all made up or put together in much the same form. If we open up other seeds, however, we may find some that have only one seed-leaf, and some that have more than two. What do you find in the maple tree seed?

The Sprouting of the Seed.—When a seed begins to grow, it is said to *sprout*. Seeds do not begin to grow in the ground in winter, nor will they sprout in summer if they are

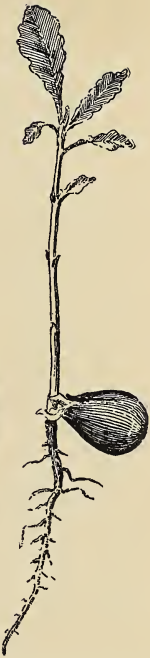
buried too deeply in the soil. We can easily cause seeds to sprout, and we can, at the same time, find out just when they will sprout. If we place some wheat grains in a *dry* dish and keep them dry, they will not sprout either in winter or summer—it makes no difference whether they are cold or warm, they will not sprout so long as they are kept dry. We therefore conclude that seeds require *water* or moisture in order to sprout. If this were not so we would have the grain sprouting in the bins and granaries. At the same time we notice how important it is to have all bins and granaries quite dry.

Now let us take three deep dishes, such as soup plates. We get three pieces of flannel and cut them so that when once folded each piece will just about cover the bottom of the dish. We place about twenty grains of wheat in each between the folded flannel. We then moisten one plate and set it away in a *cool* place, and we keep the flannel moist all the time; we moisten the second and set it in a *warm* place, in a sunny window, for instance, and we keep it moist; we fill up the third and set it also beside it in the warm place, and we keep the plate *filled* with water. We can see what changes take place from day to day by lifting up the flannel. The grain kept cool does not sprout; the grain kept covered with water so that the air does not reach it does not sprout, even though it is warm; but the grain that is kept warm, that gets some air, and that has a little moisture soon sprouts and starts to grow. We now conclude that for seeds to sprout they must have *water*, *heat* and *air*, and if any one of these three be lacking, sprouting will not take place.

By means of warm, moistened cloths we can tell whether the seed grain that we desire to sow is likely to sprout or not in the ground, and about how much is likely to grow. This is important, as seeds when they are old lose the power of sprouting. Some seeds lose their vitality or power of sprouting much sooner than others. Can you find out which these are?



How a young walnut gets out of its shell. Note the thick, fleshy tap root. Compare with Fig. 7. Where are the seed leaves?



"Great oaks from little acorns grow." The young plant feeds on the "meat" in the acorn till the root is able to get nourishment from the soil. Look again at Fig. 2.

CONCLUSIONS :—

1. Seeds will not sprout unless they get some water or moisture.
2. Seeds will not sprout when the ground is too cold.
3. Seeds will not sprout when they are in undrained soil that is full of water, because they cannot get air.
4. Seeds will not sprout when they are buried too deeply so that the air cannot reach them.

The seed is the beginning of the plant, and with the plant, as with so many other things, it is of very great importance to have a good start. This means that we should have good living seed—seed that will grow, free from weed seeds. Then we must have a good, fine, level seed-bed, on a well-drained field, so that the seed can be sown evenly and covered properly. Moderate rains and bright sunshine will cause the seed to sprout, and the young plants will soon appear at the same time in all parts of the surface of the field. This brings us to the study of the young plant, which will form the next chapter.

Describe the seeds of corn or maize, buckwheat, the turnip, the thistle, the dandelion, the strawberry, the gooseberry, the pumpkin, the grape, the cherry, the apple, the maple, the elm, the basswood, the beech, the hickory.

What is the effect of steeping seed just before it is sown? What kind of water should be used—hot, warm, or cold?

How are seeds distributed naturally?

What kinds of seeds may be easily carried by water, by wind, by birds, by animals?

Why do we find willows along streams?

CHAPTER II.

THE YOUNG PLANT.

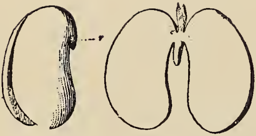


Fig. 6.—A Bean showing tip of rootlet or radicle at *r*; also with parts separated showing tip just starting to grow.

We have learned that seeds will sprout when they have water, heat, and air. But there must not be too much water, for then they will simply become soft and decay; nor must there be too much heat, for then they will be dried up and killed. We have shown how they can be sprouted between layers of moist flannel or blotting paper. When sprouted in that way their growth can be watched day by day; but this plan of sprouting seeds will not allow us to watch their growth to a very large size. If we wish to see them grow up into full-sized plants we must plant the seeds in soil. We can do so in a box of clean garden soil placed in a sunny window, or out of doors in warm weather. We may plant some peas, beans, or pumpkin seeds. Let us take a handful of bean seeds. As they are rather large in size we must cover them thoroughly with soil about an inch deep. At the same time we might put in a few seeds four, five or six inches deep, and also place three or four right on the surface, to observe the effect on them in contrast with those planted at the proper depth. We then water the soil slightly every day.

After two days we carefully take up a couple of seeds to see what has taken place. Then we put them back carefully. In this way, day by day, we examine carefully a couple of the seeds until we find them starting to sprout.

When they have once sprouted we can take up a plant every day to see what change is taking place. We should have enough plants growing so that we can throw away each little plant after we have examined it. First we find the seeds becoming moist from the water in the soil, and

Fig. 7.—Bean Seed; also young plant on right, and, in the centre, a plant showing two seed leaves, also first pair of true leaves above.

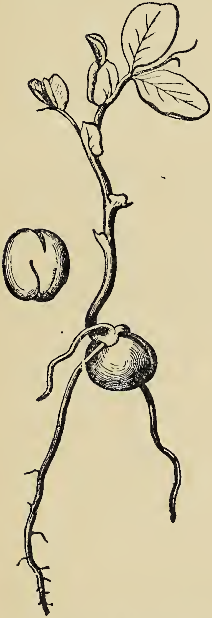


Fig 8.—Seed Pea and young pea plant.

soon turning soft. The beans swell a little and soon break open the outer covering or husk. The two thick leaves of the seed separate a little and a few fine roots push out into the soil. The little tip between the seed leaves begins to grow larger and pushes up towards the air. The plant never makes a mistake; the roots always grow out and down into the soil and the little tip

that forms the stalk always grows up into the air, whether the seed is lying upside down or not. The roots lengthen out and branch into a little bunch of fine fibres, and the stalk soon brings the two leaves above ground. Sometimes we can see the old husk of the seed still clinging to one of the seed leaves, which are generally quite smooth and simple in form. The stalk grows on higher and higher; new leaves form; little branches are thrown out; leaves form on these; and now we see the general form or make-up of the plant. By this time we observe that the two seed leaves have become thin and soon disappear. They appear to be of use only in the first few days of the sprouting of the seed and the early growth of the young plant. What is their use? They are different in shape and size from the ordinary leaves of the plant. They are thick at first, and soon become thin and disappear. They are nothing else than little sacks of food stored up in the seed to feed the young plant until it forms roots and leaves and is able to get food for itself from the soil and the air.

Parts of the Plant.—The roots spread out or go down through the soil; the stalk grows up and branches out; the leaves grow along the side and at the ends of the branches. These three parts—roots, stalk and branches, and leaves—are quite different in form and in color, and we may conclude that they also have different work to do in the life of the plant.

Fig. 9.—Tap-root, as of a carrot, showing fine hairy feeding roots.

We can easily study these three parts in larger plants. In the case of a carrot the root is thick and long and pushes itself straight down into the soil. We call such a root a *tap root*. But along this root we find a large number of fine, hairy-like rootlets, to which the fine particles of soil cling closely. These are the feeders of the big root.

In the case of a stool of wheat or oats we have

a mass of fine roots. We call such a root *fibrous*. In the case of large trees, we find large roots running off in all directions, many of them for long distances. If we take up a piece of tree root, we find the outer end covered with fresh, fine, hairy-like roots. These are the feeders of the big roots.

Fig. 10.—Fibrous root, as of grass.

How do roots grow? A man's arm is longer and larger than a boy's arm. How did it grow? Not simply by adding on at the end, for in that case the man's arm would be merely the boy's arm with very long fingers. All parts of the arm must have grown at the same time. A root would find it very difficult to grow in that way through the soil. It adds on at the end or the tip. Sometimes a root has to go around a large stone; a bend is formed in the root. How difficult it would be for the root if it had to keep pulling itself around that stone as it grew longer. Roots, of course, grow larger and thicker, pushing aside the soil and even rocks; but they lengthen at the tips and take in the food from the soil through the fine, hairy rootlets, which are always found in largest numbers near the ends of the newly-formed roots.

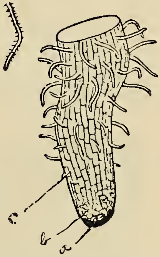


Fig. 11.—End of Root, covered with fine, hairy, feeding rootlets. *a* is tip hardened for protection; *b* is growing part; *c* is older part of root. The root pushes the protecting cap on through soil, forming new root at *b*, which soon changes to *c*.

Two other things we notice, namely, the roots do not bear leaves and they are not green. They are generally light colored inside with a dark covering. They are also quite pliable—easily bent or twisted; in fact they are made for working their way easily through the soil and around stones. Pull up a bunch of grass and observe how the roots cling to the fine soil. Also observe how crooked a tree root grows.

The stalk is compact and strong, built for holding up a heavy weight. When young the stalk and branches are green in color; as they grow older the color becomes darker and duller, and the soft, smooth skin changes to hard, rough bark. The stalk and branches are much stiffer than the roots; if they were as pliable as the roots they would not be able to hold themselves up in the form that we see. Most plants, however, are pliable enough to yield to strong wind and thus avoid being broken. The last thing to be noticed here in regard to them is that what is called "the grain" goes along and not across the branch and stalk. We can split a piece of wood along its grain, but we have to saw or break it if we wish to divide it across the grain. What would be the effect of a strong wind upon plants, trees, forests, if the grain ran across instead of along the stalks, limbs, trunks, and branches?

The most noticeable points in connection with leaves are their shape, their number, and their color. The leaf is generally flat and very thin. Its outline or form varies with different kinds of plants. Contrast the thick, needle-shaped leaf of the pine and the thin, long, pointed blade of grass with the leaves of the oak, maple, basswood, and willow.

Take a green maple leaf; draw its outline; trace the framework upon which it is formed. Then glue or paste it between two sheets of paper or cloth and dry carefully. Pull these two sheets apart and thereby split the leaf. We thus see that the leaf is a thin web stretched upon a framework of fine branches, and we observe that the branching of these ribs of the leaf varies in different kinds of leaves; further, that though the leaf is very

Fig. 12.—Section of a Leaf. *A*, row of cells forming skin on upper side; *B*, row of cells next to skin; *D*, next row of cells; *C*, air spaces in leaf; *E*, inner portion of cells filled with sap; *F*, row of cells forming under skin of leaf showing mouths or openings (stomata).

thin, yet it is made up of different layers, two skins with softer layers between.

Draw the leaves of all the different forest and shade trees found in your locality.

The new leaves of spring and early summer are green; as summer advances they change in color somewhat, and in the fall the green turns to brown or yellow or red. The young shoots also are green in color at first, becoming duller and darker in color as they become older and stiffer. But observe the many different shades of green in the leaves of different kinds of trees—even different kinds of maples show tints that slightly vary. Even the two sides of the same leaf are not of the same shade. This can be seen on a windy day when the wind blows the leaves over.

What causes the green color? Place a small piece of board on the green grass ; after a few days lift the board and observe that the grass under it has become paler in color, has been bleached out. Leave the board off and the grass will soon become green again. When potatoes start to grow in a dark cellar their sprouts are white, the tips grow towards the light, and if they reach direct sunlight they become green. We conclude from the above that the sunlight in some way or other is the cause of the green color in the leaves. (The name *chlorophyl*, applied to the green-colored matter in the leaf, means "leaf green.")

Why are the roots not green like the leaves?

Are evergreens of the same color in winter as in summer?

Why is the growth of trees less and less, or more stunted, as we go farther north?

When do evergreens shed their leaves?

Compare the cones of different evergreens.

Where do we find the most evergreen trees, and why?

Where the most deciduous?

CHAPTER III.

THE PLANT AND WATER.

THE WATER OF THE PLANT.—In a long season of drouth, the grass turns brown and withers, the leaves of the trees dry up, and shrubs and plants of all kinds droop and die. In the case of plants grown in the house, everyone knows that they must be watered regularly. When the rains are frequent, how the grass grows, and how all plant life becomes green and thrifty! Nothing more need be said to prove that *water* is one of the most important foods for plants. Further, we find some water in all plants, some fruits being made up of over nine-tenths water. If any plant, or any part of a plant, such as a piece of root, a chunk of green wood, a bunch of green grass, or a handful of leaves, be placed in a warm oven, it will gradually become lighter in weight owing to its losing water or becoming drier. Even well-dried wood will lose a little water. If we were to take 100 pounds of several substances, such as the following, and dry them out thoroughly, we would find that they would become lighter by the following amounts, that is, they would lose these amounts of water:

Roots, carrots, turnips, etc......	85 to 95	pounds.
Potatoes......................	75	"
Green pasture grass..............	80	"
Timber wood......................	40 to 50	"
Dried or cured hay...............	15	"
Grains, such as wheat, oats, etc....	10 to 15	"

We can therefore say that roots contain from 85 to 95 per cent. of water, potatoes 75 per cent., etc.

How Does the Water Get in?—We can answer this first question by carefully observing as follows: When house plants are watered, we do not pour the water on the leaves and branches, but on the soil that contains the roots. When the earth above the roots has been allowed to become too dry, the gardener sometimes sets the whole pot, earth and roots, in a pail of water until the soil has become thoroughly wet. Two pots of the same size and shape may be taken, one having a plant growing in the soil and the other containing only soil. Then place them side by side and water the soil in both with the same amount of water. It will be observed that the soil in which the plant is growing will become dry much more quickly than the soil having no plant.

If we could examine the drains coming from under two fields having the same kind of soil, one having little or nothing growing upon it and the other having a heavy crop, such as roots, corn or hay, we would see that much more water drains away from the bare field than from the field bearing a crop.

Perhaps you have noticed a bulb or a slip from some rapidly-growing plant being started in a vase or glass bottle filled with water. If you take two glass bottles of the same size and fill both with water and place a growing plant slip in one, you will notice that the water in the one having the plant slip will disappear more rapidly than the water in the other bottle. Sometimes it can be shown even more clearly by placing a few large white flowers, such as lilies or chrysanthemums, in water that has been colored red or blue. After a while some red or blue color will appear in the flowers.

We conclude from the above that the water passes into the plant by way of the roots.

How Does the Water Get Out?—It is quite evident that there is not room in the plant to hold all that goes in. Wherever we cut into a living plant we find it damp and the cells

filled up, so that as water is constantly going in by way of the roots, it must be passing out by some way.

When the soil becomes very dry and the plants, as we say, suffer from drouth, the first place where we observe the effect is in the leaves. These droop and wilt and lose their freshness, and soon after watering they become fresh-looking again.

Let us take a clear bottle and wipe it out so as to have it perfectly clear, clean and dry on the inside. Then we carefully place it over the branch of a growing plant so as to have the bottle pretty well filled with leaves. We leave it there, fastened up securely, for a time; after a while we observe a fine film on the inside of the bottle. When we take it off we notice that the bottle is damp on the inside, some water has been deposited upon it from the leaves. We observe the same kind of a film on a piece of looking-glass when we breathe upon it. In fact, we can take a piece of dry looking-glass and fasten it to a plant leaf and get a faint film of moisture from the leaf as from our breath. Further, if we try first the upper side of the leaf and then the under, we shall find that the moisture comes almost entirely from the *under* side.

We conclude, then, that the water passes out by the leaves and principally from the under surface. If we had a microscope, that is an instrument for making small things appear large, we could examine the two sides of the leaf of any plant, and then we would observe that on the under side there are a great many little mouths, or pores, or openings whereby the water can pass out, and that these are drawn up smaller as the air becomes drier so as to prevent too great loss of water. Each of these mouths or pores is called a "stoma," and when we speak of two or more we call them "stomata."

We have called these mouths or pores; they are openings through which the plant breathes, and they are generally on the under side of the leaf, several hundred or several thousand on every leaf. In the case of such a plant as the water lily, whose

large round leaves lie flat on the surface of the water, the stomata or mouths of the leaves are found to be on the *upper* side. Why has nature made this change?

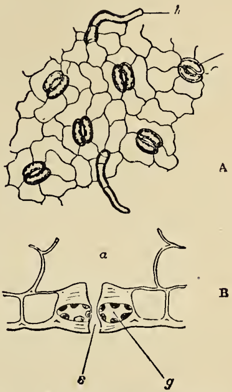


Fig. 13.—Under side of leaf. *A* shows the mouths or stomata with small hair on leaf at *h*. *B* is a section, showing stoma or mouth at *s*, the air space is at *a*, and *g* is a guard cell which opens and closes the mouth or stoma.

Animals soon suffer from thirst, although they have some water in nearly every kind of food that they eat. But plants require water quite as much. There is nothing so important in connection with plant growth as having a proper supply of water—not too much and not too little. When the rains come at the right time and in the right quantities, nearly every soil bears good crops; where no rains fall we find a desert.

CONCLUSIONS:

1. Water is found in all plants and in all parts of living plants at all seasons of the year.

2. Water is necessary for the life and growth of plants.

3. Water goes into the plants through the hairy rootlets at the tips of the fresh roots and passes out through the thousands of tiny mouths on the under side of the leaves.

4. The mouths or breathing pores are called *stomata*. These open wider as the air becomes damp and partially close as the air becomes dry.

SUGGESTIVE:—

What gives rigidity and firmness to a geranium leaf?

Which contains proportionately the more water, an apple leaf or an apple twig?

CHAPTER IV.

THE PLANT AND THE SOIL.

The Power of Water to Dissolve Substances.—If we drop a little common salt into a glass of water, it will disappear from sight; but if we taste the water we find that it is salty—the salt has been dissolved in the water. If we pour out the salty water into a saucer, and set it in a warm place, the water will gradually become less and less, and we shall soon see the white salt reappear as a fine white crust. We know now that salt is soluble in water. If we keep on adding salt to the water in the glass we shall find that after a while no more salt will be dissolved, but what we add will remain undissolved in the bottom of the glass. We conclude, therefore, that the water can dissolve a certain amount of salt and no more—that there is a limit to the power of the water to dissolve the salt. We can make the same trial or experiment with other substances, such as sugar, saltpetre, etc.

But all substances are not soluble. If we place some sand in the glass of water it will not dissolve. If we stir up some road dust in a glass of clean water, the water will at once become dirty; but after a while the dirt will settle and the water clear up. Sometimes when we examine salt by putting a little in water we find a small quantity of hard, gritty substance settling at the bottom undissolved—this is not salt, but an impurity in the salt. If there were any sand in the sugar it would not dissolve. A nail will not dissolve in the water, though it can be more or less dissolved if there is a little acid in the water. If we take a handful of hardwood ashes and stir them up in a bowl of water, a large portion will settle to the bottom undis-

solved, but the water will feel and taste soapy. There is evidently something soluble in wood ashes, and also something insoluble. If we take coal ashes instead of wood ashes, we shall find that there is little or nothing soluble in the coal ashes. It is evident, therefore, that wood ashes contain much more soluble matter than coal ashes. This soluble matter is food for plants. If we take a piece of limestone and pour water upon it we shall find that little or no change takes place; but if we use a little weak acid (even vinegar will have some effect), we find that the limestone will dissolve. If, instead of limestone, we take freshly-burnt lime—quick-lime—we find that the water will take up some of the lime, as we can tell by tasting it.

We conclude that some substances are quickly soluble in water, some slowly soluble, some insoluble, and that weak acids will have the effect of dissolving some substances, such as limestone and iron, that do not dissolve in water alone.

Further, we find that water can dissolve only a certain quantity of any substance—that its power of dissolving is limited; and when the water evaporates or passes off into the air, the substances, such as salt, sugar, and lime, that were dissolved in it, reappear as salt, sugar, and lime.

If we pour milk through a fine strainer, the milk all passes through, and the dirt that was not dissolved remains behind. If we stir up some hardwood ashes in a glass of water and then pour it through a very fine strainer, we find the undissolved ashes remain behind, and the water that passes through is soapy in taste.

We conclude that the substances dissolved in the water go along with the water wherever it passes in the liquid form.

Take a clean unglazed earthen flower pot; stop up the hole in the bottom, fill it with water, and throw into the water a handful of salt. Allow the pot to stand undisturbed. After a while a deposit will appear on the *outside* of the pot. Taste it, it is salty. Explain.

How Mineral Food Gets into the Plant.—We have before learned that water goes into the plant through the roots and passes out by the leaves; there must therefore be a movement of the water through the plant; and we thus conclude that the water can carry along with it into the plant, and through it, some substances taken up in solution from the soil, that is, that it will take into the plant whatever it finds in the soil that can be dissolved. This is not quite the case, for the roots appear to have the power, in large measure, of taking up the substances that the plant requires; the roots have a certain amount of what may be called "selective" power.

One thing more may be mentioned in connection with the taking in of food by the roots; there is a small amount of weak acid found in the ends of the roots, so that wherever the fine, hairy rootlets come into contact with the soil they are helped by this weak acid to dissolve small quantities of material that the water alone, without this acid, could not take up. It is because of this that we frequently find the marks of plant roots on the face of hard rocks, showing where the roots by their acids have eaten out some of the rock.

When we burn wood in the stove we have left what is called the ashes. If we burn up some straw, or grain, in fact any kind of a plant, we have left some ashes. This ash is earthy in nature. Sometimes it is called the "mineral matter" of the plant. It has all gone into the plant by way of the roots, dissolved in the water of the soil. When this ash or mineral matter is taken apart and examined by a chemist, it is found to contain such substances as compounds of lime, soda, and potash. From 100 pounds of plants taken, we get one to five pounds of ash or mineral matter; we therefore say, that the ash or mineral matter forms from one to five per cent. of the whole plant, and it has all come from the soil.

The mineral matter of the soil, after being dissolved in the

water of the soil, passes into the plant, is carried by the circulation of the sap to all parts, and is used in helping to build up the various parts of the plant. When matter gets into the plant in this way that is not required, some of it may become deposited in various parts of the plant, but much of it is carried to the outside of the leaf and of the bark, and left there as the water evaporates. In the case of some plants, more mineral matter is taken up from the soil than the sap can hold in solution, and some of the salts are found in a solid form in the little sacs or cells of which the plant is made up. These are often seen by a magnifying glass or microscope in the form of crystals either in the cells or in the walls of the cells.

CONCLUSIONS:

1. The water of the plant comes from the water of the soil, hence the importance of rains.

2. All of the mineral or ash material of the plant comes from the soil, being carried into the plant in solution through the roots.

3. The mineral matter is carried to all parts of the plant in the circulation of the sap.

4. Some of the mineral matter that is not needed by the plant is given off from the outside of the leaves and through the bark.

5. It is very important to have the mineral or ash material required by the plant in as soluble a form as possible in the soil, hence the importance of good cultivation and of proper fertilizing or manuring.

CHAPTER V.

THE PLANT AND THE AIR.

THE COMBUSTIBLE PART OF A PLANT.—When we dry any plant thoroughly, we drive off the water that it contains; when we burn up this dried portion, we have left the ash. But what about the portion that has been burned up? What was it and where did it come from? All plants contain fibre—woody fibre as we may now call it; this has been burned up. Some plants, such as sugar beets, sugar cane, and corn, contain some sugar. Other plants, such as potatoes, contain a large quantity of starch. In burning, all the fibre, starch, and sugar are burned up. Then such seeds as flaxseed and cotton seed contain oil. There are other substances, also, that we should know. For instance, if we chew a few grains of wheat, we find after a short time a small quantity of a gummy substance remaining in the mouth—it is called *gluten*. Then you all know that from many different fruits a beautiful clear substance is got by boiling, known as jelly. Perhaps we have mentioned enough—fibre, starch, sugar, oil, gluten, jelly substances—all these and many others similar to them are found in plants. They do not pass off when the water evaporates, nor are they left behind in the ash. They are all consumed or burnt up when the plant is burned.

What do they consist of? In burning any plant slowly, the first thing that you notice is that the plant becomes black—charred; and by very slowly burning it we can turn it into a black mass that we call charcoal, somewhat like coal in appearance. This black color is given to it because of the *carbon* which it contains. If we could put some of this

charred plant into a strong iron vessel, having only one small open pipe leading from it, we would find that there were gases coming away that would burn with a flame; and when you are further advanced in the study of chemistry you will be able to prove that these gases contain, besides carbon, another substance also, called *hydrogen*.

In addition to these two, carbon and hydrogen, both of which will burn in the air, there are in the plant small quantities of *nitrogen* and *sulphur* and some *oxygen*. All of this cannot be proved by you at present, but you will now have to accept the statement that these parts of the plant that are burned up contain carbon, hydrogen, oxygen, nitrogen, and sometimes sulphur in varying quantities. The chemist, for shortness, refers to them often simply by the first letters, thus: C H O N S.

WHAT THE PLANT GETS FROM THE AIR.—The next question is as to where these elements came from and when they got into the plant. If they came from the soil they must have been contained either in the water or in the salts or mineral matter carried in through the roots. Water is a compound of only two substances, hydrogen and oxygen. Two of them, then, may have come from the rains and soil water. The sulphur and the nitrogen may have come from the soil in part or in whole, for we sometimes find soluble compounds of sulphur in the soil, and also compounds of nitrogen. But the carbon which is found in such large quantity does not come from the water, nor from the mineral matter of the soil. There is only one other source, and that is the atmosphere, or, as we say, the air. If the carbon comes from the air, we at once conclude that it gets into the plant through the leaves. And how wonderfully well supplied is every plant with leaves for taking in food from the air!

The air is a mixture of gases. Coal and charcoal are almost pure carbon, so that we think of carbon as being a solid. And

so it is. But in the air there is a gas called carbonic acid gas. It is formed wherever carbon is burned. The carbon unites with the oxygen gas of the air and forms a compound, a gas, that is called carbonic acid gas. This is the source from which the plant gets its carbon.

There is only a very small quantity of this carbonic acid gas in the air, but the plants have a large number of leaves and they are broad and thin, and the air is moving more or less all the time, so that the plant has no difficulty in getting all the carbon that it requires. The carbonic acid gas of the air goes in through the leaves; the plant takes up the carbon for its own use and sets free the oxygen gas with which the carbon was united. Just here we might mention that all animals are constantly breathing out carbonic acid gas from their lungs, and that when too much of it is present the animals will be smothered. We feel the effect of it when shut up in a close room. Plants take up this carbonic acid gas, keep the carbon and set free the oxygen, so that plants are constantly purifying the air for animals, and animals are constantly producing carbonic acid gas to feed the plants. Nature has in this way made plants and animals dependent upon each other.

The starch of potatoes, the sugar of beets, the jelly of currants and apples, the oil of flaxseed and the fibre of flax and of all parts of plants are made up entirely of the three elements —carbon, hydrogen and oxygen (C H and O).

The plants get all the carbon from the air, and the hydrogen and oxygen can all be got from water, which, as we have said, is a compound of hydrogen and oxygen, so that starch, sugar, jelly, oil and fibre are made up by the plant from what comes from water and the air. When a farmer sells from his farm sugar or butter (oil) or fibre he is selling what in the first place came from the rain and the air, and thereby he does not rob the soil so much as when he sells grain or hay, since these contain mineral or soil material.

We have said that the quantity of carbonic acid gas in the air is very small ; there are only three parts in every ten thousand parts by volume. The air, or atmosphere, is made up almost entirely of nitrogen and oxygen, mixed together, not united, in the proportion of about four to one ; that is, in every one hundred volumes of air there are nearly eighty parts of nitrogen to a little over twenty parts of oxygen. In addition, there are very small quantities of other gases, such as ammonia, but we need not refer to these here. The facts now to be fixed in the memory are that the plant, through the leaf, does not take up the nitrogen and oxygen which are in such large quantities, but does take up carbon from the carbonic acid gas which exists in such small quantities, and from this carbon, along with the elements of water, it builds up the larger portion of its entire structure. How it does this is largely a mystery.

CONCLUSIONS :

1. Besides the water and the mineral matter of the plant, which come in through the roots, there are in plants large quantities of such substances as starch, sugar, oil, and gluten.

2. All of these substances contain carbon.

3. This carbon comes from the carbonic acid gas of the air.

4. Animals breathe in oxygen and breathe out carbonic acid gas through their lungs ; plants take in carbonic acid gas and give off oxygen through their leaves.

CHAPTER VI.

STRUCTURE AND GROWTH OF THE PLANT.

The Sap.—All the water used by the plant enters through the roots, and along with it comes the material that we call the mineral matter, together with the nitrogen that the plants require. The stalks and branches form the frame work of the plant—its body, so to speak. The leaves give off the water taken in by the roots, and also take up carbon from the carbonic acid gas of the air. Now if the water goes in by the roots and out from the leaves it must *move* through the plant—through the roots to the stalk, thence to the branches, and so on to the leaves. This water contains many substances in solution (sugar, salts, and other things); we call it sap, and the movement is called "the circulation of the sap." We have already referred to the fact that a limb will split lengthwise, not across. Sometimes, as in flax and in the inner bark of basswood, we can pull off long fine strings of fibre. These long fibres that run up and down, or lengthwise, are nothing else than strings of little cells, and in circulation the sap passes on through from one to the next.

Frequently you see a hollow tree that is alive and thrifty; and when you cut across a large tree you notice that the sap is principally in the outer portion. The outer rings of wood are much wetter than the inner or heart wood. We conclude, then, that the sap moves principally up and down through the layers or fibres of the plant near the outside, just under the outer rough bark. The life of the body of the plant is then mainly near the outer bark. When we girdle a tree we are apt to kill it; we can cut a small nick into it, we can tap it, or we may bruise a piece of the bark, and we do not kill it. Now you see the reason.

WORK OF THE LEAVES.—The circulation of the sap brings the water and material taken up from the soil to the leaf, where also is found the carbon taken up from the air. And it is in the green growing leaf that all this material is worked over into such forms as the plant can make use of. The leaves, we may say, are both the lungs of the plant and also the stomach. If fire burns the leaves of a tree, or some blight or disease attacks them, or insects devour them, the tree becomes weak and in many cases soon dies.

We observe the vitality of any plant in the leaves; and we should always try to keep the leaves fresh and free from attacks of all kinds. The greenhouse gardener carefully washes the leaves of his valuable plants, and the fruit-grower sprays his trees and bushes for this purpose. When the leaves have worked over all the food from the air and the soil (that is, digested it, as we digest food in the stomach), it is carried away in the sap to all parts of the plant—to make root in one place, more leaves in another, to increase the wood in the branches, to form buds, or blossoms, or fruit; in fact to build up the plant in all its parts. How all this is done and no mistake is made—how leaves are formed in one place and roots in another, and buds in another, is, as we have said before, largely a mystery; just as it is a mystery how hair is formed on your head, teeth in your mouth, and nails upon your fingers.

We have another point to notice in regard to the leaves. Cut off several long switches or branches from a willow, a maple, an oak, a spruce, and currant bush. Observe how the leaves are placed. They are not attached by chance. In some cases two leaves grow out from the same part on opposite sides. They are said to be *opposite*. In others there is first one on one side and then the next above on the other side. They are said to be *alternate*. Then, if you start with the first leaf and draw a line to the next, and then to the next,

and so on, you find that the line goes around the branch in a spiral direction. By closely observing all these different branches, you find that in all cases there is a certain definite order of arrangement. Further, you find that just as the leaves of any one kind of tree are nearly alike in outline, so they are all nearly alike as to their form of arrangement. Find out this mode or form of arrangement of leaves on the different trees and shrubs with which you are familiar.

When the leaves have done their work they lose their bright green color, turning duller, sometimes brown or almost white, sometimes yellow, sometimes red and many-colored. In the case of one class of trees, such as maples, oaks, etc., they fall off the branches—such trees are called *deciduous*, to distinguish them from the *evergreens*. But even the evergreens become duller in the fall, and the new growth of the spring is of quite a different green from that of the old growth.

The Buds.—The leaves do not grow into branches or flowers. The buds come every year (in the fall and in the spring) in the angles or "axils" of the leaves or at the ends of the branches, so that the arrangement of the leaves is also the arrangement of the buds. Some buds grow into branches and some into blossoms. When a bud grows at the end of the branch it, of course, by its growth lengthens the branch; when it comes on the side, by its growth it forms a side branch. When we "stop" a raspberry bush by pinching off the growth at the end, we cause the side buds and branches to grow out, and thereby make the plant become bushy.

If you remove a bud formed in the fall, covered with a waxy substance to protect it in winter, or if you take a bud formed in spring or summer, and carefully open it, you find it is a compact mass of small leaves—it is a little branch compressed and packed away; and the opening of the bud is nothing else than an unfolding of these leaves as they

grow larger. The life of the tree starts the leaves growing, and the buds burst and open up, some to form leaves and branches and some to form blossoms.

Blossoms.—Let us take a simple blossom like a yellow buttercup. First we find five small leaves arranged around the outside. These form what is called the *calyx*, and each of these five leaves is a *sepal.* Just above these are five leaves of bright yellow color forming the *corolla*, each of which is called a *petal.* Next inside the corolla are a number of little stems or fine stalks, with tiny balls on their tips covered with fine dust. These are called *stamens*, and the dust is *pollen.* Right in the centre are some more little growths called the *pistils.* This blossom, then, has four parts—calyx, corolla, stamens, and pistils. If we take a buttercup, we can easily examine the parts by pulling them off one by one, beginning at the outside.

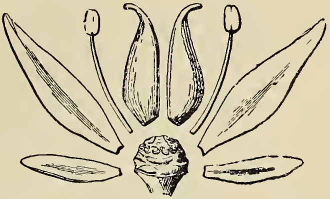


Fig. 14.—Parts of a Blossom, as follows: End of stalk or "receptacle" in centre; two leaves or sepals of calyx on outside; then two leaves or petals of corolla; then two stamens; then two pistils.

Forming Seed or Fruit.—What is the use of these four parts? The calyx and corolla are simply two rows of leaves, green and yellow, arranged around the two other parts to protect them. Observe their form in the closed bud. They guard the more valuable portion, the pistils and stamens, and when their work is done they drop off. The fine dust or pollen from the stamens drops on the top of the pistils.

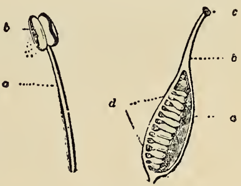


Fig. 15.—Stamen and Pistil. Stamen on left showing *a*, the stalk, and *b*, the head, covered with pollen dust. Pistil on right showing *c*, the stigma on which the pollen falls; *b* the style, and *d* the ovary containing the seeds, *a*.

Fig. 16.—Complete Blossom, having calyx, corolla, stamens, and pistils.

Sometimes the wind blows it over; sometimes the insects carry it on their bodies and legs. As soon as the pollen reaches the upper end of the pistils, growth starts within the pistil, beginning at the top (the *stigma*) and continuing down through the fine stem (the *style*) until it reaches the main inner part (the *ovary*). It is in this part of the blossom that the seed is formed. Figures 14 and 15, showing the different parts of a blossom taken apart, will help to understand what takes place. To form seed, then, the pollen from the stamens must reach the pistils. In some plants we have them side by side in the one blossom, in other plants some blossoms have only stamens and others only pistils. In this latter case the pollen must be carried by the wind, or by insects, such as bees, as they go from flower to flower. The seed forms in the ovary of the blossom after the pollen has fallen from the stamens upon the pistils.

Fig. 17.—Incomplete or imperfect Blossoms. The upper one has stamens, but no pistils (male blossom); the lower one has pistils, but no stamens (female blossom).

Compare the flowers of the apple with those of the cherry, and the flowers of the pear with those of the plum.

CHAPTER VII.

THE NAMING AND CLASSIFICATION OF PLANTS.

The many millions of human beings in the world may be arranged in classes or great families. Sometimes the basis of classification is their color; thus we have the white race, the black race, the red race, etc. The white race, also, may be divided in various ways. For instance, we speak of the English-speaking people, the French people, the German people, etc. The Indians are divided into tribes. These classifications are based on color, height, form of body, language, and certain habits or characteristics. In a similar manner it is advisable to arrange the great plant world into groups or classes—all those somewhat alike in one class, all others somewhat alike in another class, and so on. To these various classes names must be given. These names are what we call the scientific or botanical names. They are not always much like our common names of plants. The common names may vary in different places, but the botanical names must be the same the world over. The botanical names are not so familiar to us as the common names, hence they appear to be very difficult; but in studying plants, in naming them, and in referring to text books on botany, it is necessary to become more or less familiar with them.

How are we to study a plant, to describe it, to know the plant referred to in any botanical work? How are we to *identify* any plant? There are the four parts—the roots, the stem, the leaves and the blossoms. The leaves really include those parts which we call the blossoms or flowers, as these are made up of changed leaves; but for the present we may say

that these are the four parts named. In studying or describing any plant, therefore, we find out the nature or make-up of its root, stem, leaves and blossom. In regard to the root, for instance, we observe whether it is tap-rooted or fibrous. We note the color and form of the stem. We observe the shape of the leaves and their arrangement on the branches. In the blossom we note the form, number and arrangement of the sepals or parts of the calyx, and of the petals or parts of the corolla; also the number, form and arrangement of the stamens and pistils.

If we carefully observe a buttercup and a marsh-marigold we find that in the main they closely resemble each other, yet there are differences in their form and they grow in different locations. Meadow rue, columbine, anemone and hepatica also have a strong family resemblance to these two plants. These are all classed together in one great order or family known as the *Ranunculaceæ* or crowfoot family.

The wild mustard of our grain fields and the weeds shepherd's purse and pennycress are classed in another order or family known as the *Cruciferæ*, so called because of the arrangement of the four petals forming a cross-like corolla.

The blossoms of the field pea, sweet pea, bean, clover and locust tree are much alike. These are all classed in one family —the *Leguminosæ* or legume family.

Compare the blossoms and leaves of the apple, pear, plum, cherry, strawberry and hawthorn with the wild or single rose. They all belong to one family—the *Rosaceæ* or rose family.

The carrot and the parsnip form a cluster of flowers in form called an *umbel*, hence these belong to the family *Umbelliferæ*.

In many common plants we have the flowers in a dense or thick head like the blossom of a field daisy or of a sunflower. The thistles, burdocks, everlasting, golden rod, aster, yarrow, dandelion and lettuce are other members of the same family —the composite family, or *Compositæ*.

PART II.

CHAPTER VIII.

NATURE AND ORIGIN OF THE SOIL.

All the plants grown upon the farm or in the garden grow in the soil; even those that appear to be growing in streams and marshes have their roots in the soil beneath the water. Sometimes we see plants grown in water only in the house or greenhouse, but most of those found there are grown in pots filled with soil. The plants found on the surface of rocks and on old rail fences are of a low, simple order. We may then conclude that most of the plants that we are now familiar with require soil, and we therefore shall study for a while the soil, its nature, its origin, and its improvement.

KINDS OF SOIL.—Sandy soil is made up principally of sand. If we take a handful of dry sand we find that it consists of small hard grains that are easily mixed together. If we moisten it, it will cling together and can be moulded into various forms, but when it dries the particles all fall apart into fine sand as before. Then there is clay of various colors, sometimes red, sometimes almost white, sometimes nearly blue. If we moisten it we can mould it, but when it dries it keeps its shape and becomes hard. We readily see the difference. When we walk over wet sandy soil and wet clayey soil, the former, when dry, readily rubs off our boots, the latter sticks. Sand is used for making moulds in the foundry and clay is used for making models by the artist; the

former readily falls apart after being taken out of the boxes and can be used again, and the latter when moulded and worked keeps its shape as it dries.

Make two sets of objects (such as balls, cubes, cups, vases or simple figures of small animals), one set from wet sand and one set from clay. Place them in the sun or near the stove and observe the effect of drying.

We see that sand as it dries does not stick together, and clay as it dries does stick together and also sticks to other objects. We now understand how it is that wet clay is sticky; it clings to the plow and the harrow and to the feet of the horses and is hard or heavy to work. Sandy soil is said to be light and clay soil to be heavy, not because of their weight, but because the former is easily worked and the latter is harder to work. If we watch closely the drying out of the two sets of objects that we have moulded we shall observe further that the sand dries out more quickly than the clay; the latter holds on to the water longer. Clay soils are usually wet soils; they are more apt to have water in them than sandy soils.

The third class of soils is usually dark in color, from light brown to dense black, such as are found in the woods where leaves and branches have decayed, and in low pastures and swampy places. This soil is made up of the refuse of leaves, branches and roots of plants. Sometimes we can see pieces of half-decayed or rotten plants; sometimes there are very slight traces of the original form of the plants. This soil has, however, all come from former plants. We call such a soil a vegetable soil, and this dark colored loose material formed from the decay of vegetable matter is called *humus*. Notice how it differs from both sand and clay. It is light in weight and easily worked and it holds water readily.

Place a handful of swamp muck or leaf mould (humus) on an iron fire-shovel and carefully set it upon the burning coals. It dries out, then burns away until only a small quantity of ash is left. Place some wet sand on the shovel and heat, and then a little wet clay. What is the result?

These, then, are the three principal parts of soils—sand, clay, and humus, but in many cases we find them mixed together or one above the other. If sand is the principal part of the soil we call it a sandy soil; if clay, a clay soil, and if humus or muck, a vegetable soil. A loam soil contains a mixture of sand and clay with some humus, and such a soil is usually best fitted for growing most of the crops of the farm.

ORIGIN OF THE SOIL.—We already know where the humus or vegetable matter has come from, and, as it was formerly parts of plants, we conclude at once that it must contain some material for feeding new plants. But where did the sand and the clay come from?

Perhaps you have never before asked that question, thinking that the clay and the sand were always in the field in that form. This, however, is not the case, although they may have been there for many years, perhaps for hundreds of years, perhaps for thousands. Why do we say that they have not been there for all time? Well, if we go to the shore of a large lake we see fresh sand being washed up day by day by the waves. If we go to the banks and mouth of a large river, or even of a small stream, we see sand and clay and vegetable matter being washed down, carried away, and spread out to form new layers of soil. If we go to the face of a high rocky cliff we can see the great rocks being gradually broken down and changed into piles of coarse stone, and later into finer material, and still later into sand and clay. But if we can go to a range of mountains or high hills we shall see more clearly the change of great rocks into fine soil.

Under our soil we find solid rock. In some places the rock is at the surface, and we can see it becoming weathered and rotten. The outer surface is softer than the interior. In other places the rock is just under the surface. In some places we have to go very deep to find the rock, but it is always there, to be found if we only go deep enough. All of our sand and

clay have come from these old rocks, sand from one kind of rock, white clay from another kind of rock, blue clay from another. The nature of the soil will therefore depend largely upon the nature of the rock from which it came. This sand or clay may have come from the breaking up of the rocks that are to be found just under the soil; in that case the soil is likely to be shallow. But usually it has come from rocks at a distance, a long distance it may be, and has been carried to its present place by water and ice, and spread out over the old rocks. In this latter case the soil may be very deep and mixed. We can now explain why the soil in some places is quite different in its nature from the rocks under it, and why there is such a variety in the same locality and on the same farm. One field may be clayey, and across a stream we may find a sandy soil—they have come from different places, and have been washed down by the waters and spread out at quite different times.

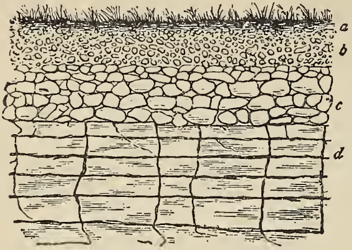


Fig. 18.—Soil formed from rock underneath. *a* soil with grass growing in it; *b* subsoil, coarser and more rocky; *c* coarse, loose rock; *d* rock in layers, cracked. *d* changes to *c*, *c* changes to *b*, and *b* to *a*.

A step farther back can now be taken. We go to the hills —to the great piles of rock. We observe that the old rock is weathered. If we break off a piece, the fresh surface shows a different appearance from the old weathered surface; it is generally harder. We can rub off some of the old weathered surface; what we rub off is the weathered rock—fine sand or fine clay. We observe long cracks or crevices, some narrow and fine, some wide and deep. The rains find their way into

these cracks and fill them up. Then winter comes on and the water in the cracks freezes. What will happen then? Just what happens when the barrel of rain water freezes, or the down pipes on the house freeze solid, or the bottles of canned fruit in the cellar freeze. There will be a bursting. And even though the quantity of water is small, it must expand, the rocks must give to make room for it. The cracks are made larger, a little of the surface is broken away, or a huge shoulder of the rock is burst off. Gradually, year by year, the rocks are thus broken up by the frost, the atmosphere wears them away, and the rains wash them down. The rocky cliffs are slowly broken down, and the ice, as it slowly moves down the sides of the mountain, scrapes and scratches off more and more. This

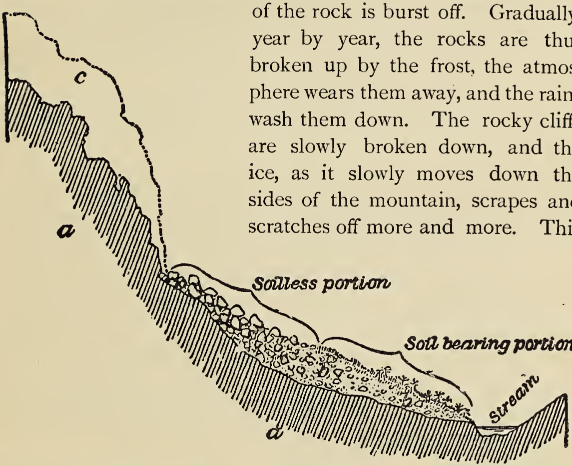


Fig. 19—Soil formed from hill rock at a distance. *a* is solid rock of a hill or mountain. Rock at *c* has been broken off by rain and frost and thrown down to foot of hill; coarsest rock lies in heaps forming soilless portion; finer rock has been carried further down where some plants, as trees and grass, grow. Finest soil is being washed into the stream to be carried away and spread out, forming layers of soil more or less level, on which crops are grown.

material is washed away—the larger pieces but a short distance, the smaller pieces further, and the finest sand and clay carried far away, to be dropped or spread out somewhere to make soil. Seeds are dropped by the birds or blown by the winds; some plants sprout, grow, die and decay, and form a

little humus. More plants grow and more humus is formed, until out of the material that came from the hard tough rocks and the decay of roots and leaves a fine soil is formed, sandy in one place, clayey in another, and loamy in another.

Conclusions :

1. All our soils have come from the breaking down of rocky material and the decay of former plants.

2. Soils may be classed as follows : Sandy, clay, loam, and vegetable or humus soils.

3. The texture of the soil depends upon the amount of sand, clay, and humus mixed together forming it.

4. The nature of the soil depends to a large extent upon the nature of the rocks out of which the sand and the clay have been formed.

5. The rocks have been broken up by the action of the air, the freezing of the rain-water in the rocks, the grinding of ice, and the downrush of rains and streams.

6. Some soils have been carried about from one place to another, and spread out by ice, snow, streams, and even to some extent by the wind.

7. Some soils have been formed out of the rocks beneath them, and from the decay of plants growing upon them.

8. Some soils, such as swamp soils, have been formed almost entirely from the decay of plants.

Suggestive :—

What class of plants are most useful in improving the soil, those with shallow growing roots or those having deep growing roots? Have you observed any difference between the roots of clover and of timothy?

CHAPTER IX.

TILLING AND DRAINING THE SOIL.

WEATHERING.—If we leave a piece of iron exposed to the damp air it soon becomes rusty; if we keep it in a dry place or put it under water so that the air cannot reach it, it will not become rusty so soon. Vegetables left in a damp cellar, or thrown out on the ground, soon decay. Pieces of wood, if left long enough, will rot and decay, first becoming brown and later on crumbling to a fine, black substance, the same as the humus of the soil. Harder substances, such as bones, will in time decay and wear away. An old brick when picked up is found to have lost its sharp corners and edges and to have become smaller than when first made. As we examine object after object, we find that there are very few things that do not become changed through the effect of the air, dew, rain, frost, snow, and ice. In a previous chapter we have referred to the oxygen and the carbonic acid gas of the air. These are the two substances in the air that cause many of the changes—rotting the stumps, charring old leaves and roots and branches, wearing away the boulders in the field, and dissolving lime out of the rocks.

If you thrust a stick into the coals it will catch fire and burn. Blow out the blaze and you have a charred stick. If you throw another stick of the same kind out on the ground, or bury it just under the soil, after many months it will be found to become brown and then almost black—it has become charred also, but it has taken a long time. The oxygen of the air has burnt up some of it in both cases. If we go to an old

limestone bridge where the rains beat upon it, we notice that where the water trickles down, some of the limestone has been washed out, and, in some places, long stone "icicles" have formed. The limestone has been dissolved out by the carbonic acid in the water. Water in the soil contains some carbonic acid, and the air contains carbonic acid gas; so that we have in this an explanation of the hollowing out of caves in limestone rocks, the breaking down of limestone cliffs, and the rapid changes that take place in limy soils.

EFFECTS OF DRAINING.—We take up a handful of vegetable soil—swamp muck, for instance, or wood mold—it is easily ground up between the fingers; there does not appear to be much rocky or sandy material in it. If we shake it up in a bottle of water, we find that the water becomes more or less brown in color; some of the substance has dissolved, but only a little. In order to get this material into a soluble form, the air must be allowed to work upon it. But the air cannot get into it unless it is drained.

Take two tin cans or tight boxes; fill one with wet muck from an undrained, swampy field, and fill the other with dry leaf mold. Plant a few seeds of the same kind in each, and observe how much better the dry, well-aired leaf mold is for the growing of valuable farm plants than the wet swamp muck.

Wet, swampy soil needs first to be drained and then to be well worked over, so that the air can get in through it to weather it. There is another reason for letting the air into the wet, swampy soil, and that is, it will *sweeten* it. Vegetable soils that are water-logged are sour, or acid; and seeds will not sprout nor plants grow well in sour soils. The air contains some ammonia, and this, when it gets into the soil, changes it from a sour to what we may call a sweet soil—it takes the sourness out of it. If a little lime be scattered over the drained soil, this sweetening will be hastened.

Then, again, wet, swampy soils are usually cold, because of the water that they contain. When we wish to cool a room on

a hot day, we sprinkle the floor with water. As this water evaporates, or passes off into the air, the floor becomes cooler, and that cools the air above it. We may look upon a swampy field as a great room, the floor of which is the soil. If the soil is kept wet, the floor of this field will be kept cold. Water is not easily warmed up or heated. A dry soil, or a soil well drained, is warmed up by the sun more easily than a wet, undrained soil.

If you place a cup (stoneware) of water, a cup of wet sand, and a cup of dry sand on the top of a warm stove, you will find that the dry sand becomes hot much more rapidly than the wet sand, and the wet sand much more rapidly than the water.

Again, if you wish to heat a pan of water, or to boil the kettle, you place it over the fire, not beside the stove, nor under the stove. The sun is the fire that heats up the soil and the water in it, and it is *above*, so that the effect of heating the water in the soil is very small.

We have, then, three reasons why the presence of too much water in the soil keeps the soil cold. We must get the water out of the soil by drainage, so that we can thoroughly work the surface of the soil; so that the air can get into the soil to sweeten it and help the decay of the humus; and, also, so that the soil can become warmed up early in spring for the sprouting of seeds and the early growth of the plant.

All that has been said here in regard to humus, or mucky soils, applies also to sandy, loam, and clay soils, except that sandy soils are not so much in need of special drainage —in most cases they drain themselves. The clay soils, when well drained, do not bake upon the surface as they dry out, and they are much more easily worked. The stickiness of clay can be somewhat overcome by the use of lime.

If you shake up some clay in a bottle of water, and then throw in some finely-powdered lime, you will observe a peculiar effect upon the fine clay —it will become flaky or coagulated and the water will clear up.

The thorough drainage of clay soils, then, is most important

to get the water out and to let the air in. Then thorough working should follow. The soil is plowed up in ridges in the field, every furrow straight and clean cut, glistening in the sun like metal in many places. But when the frost has torn it to pieces during the winter, we find a great improvement in the texture of it in the spring. The good effects of plowing and harrowing will not appear on most clay soils unless the land is first thoroughly drained. Drain the soil and let the air work for you, breaking up the coarse particles in winter and working over the particles in summer into soluble form for plant food. Perhaps you do not realize how much of the soil is still rocky and needs to be worked over.

Take a deep bottle of clear water, and drop a handful of soil into it; shake it up a little, then take a small stick and slowly stir it. The heaviest pieces will settle at the bottom, the smaller above, and the lightest on top. Notice, now, how much coarse, stony material there is in this soil.

Place a little sand, clay, or loam soil under a good magnifying glass, such as is used for examining grain. The soil looks like a pile of small stones. And that is just what it is—a mixture of fine stones with vegetable matter or humus in it. These small pieces of stone came from the great masses of rock on the hillside. How did they come to be so broken up and worked over? The air got at them, and the dews, and the rain, and the frost. Then if we open up the under-soil by under-drainage, and thoroughly open up the surface soil by tillage and cultivation, the air and the rain and the dew and the frost will go on working over these fine stony particles, forming soluble matter that can go in through the roots and feed the plant.

Thorough drainage and thorough tillage—these are the two main points in improving all soils. They are even more important than manuring. This word manure is the same as manœuvre, which means to "work by hand;" the draining of the soil and the tilling are means of fertilizing or manuring.

Did you ever notice how large a plant the flower grower produces in a small pot of earth? Examine the pot; it is porous, and has a *hole* in the bottom. The soil is well-drained and the air can get in among the roots that have grown so thickly all around next to the pot—close to the places where the air can come in.

CONCLUSIONS:—Plowing, digging, harrowing, and other means of tilling the surface soil have the following effects:—

1. The coarse soil is broken into finer particles.

2. The soil is mixed, rich and poor, fine and coarse.

3. The air is allowed to get into the soil.

4. Growing weeds are killed. Weed seeds are first started growing and then the young weed plants are killed.

5. Insects and their eggs are disturbed and destroyed.

6. Well-tilled soils do not suffer from drouth so much as uncultivated soils.

Draining the soil has the following effects:—

1. Standing water is taken out of the soil; plants will not grow in stagnant water or in sour soils.

2. Cold soils become warmer and can be planted early.

3. The rains can go into the soil, instead of running over the soil and washing away the fine surface soil.

4. The air can get into the sub-soil, and thus rapidly work it over into matter available for plants.

5. The plants root deeper, thereby having more soil from which to get food, and a better chance to withstand drouth.

How is water held in the soil?

What is free water? Is the plant benefited by the presence of large quantities of free water? The remedy is a good system of drainage.

What is understood by capillary water?

What kinds of soils contain most water in this form?

What effect has deep plowing in the spring, followed by frequent shallow cultivation during summer, upon this source of water supply?

What is the effect of an earth mulch, and how is it secured?

CHAPTER X.

IMPROVING THE SOIL.

"Feed the soil if you would have the soil feed you."

EXHAUSTING THE SOIL.—Sometimes we see a very heavy crop of corn, oats, barley or roots grown in the open field. In such cases we generally find that there is a good soil, well-drained, and that the season has been very favorable. As a rule, however, we find much larger crops grown in the garden of the farmer, and still larger grown in the little plot of the market gardener. The flower grower, however, produces still heavier crops in his small pots and neat beds. If we observe closely we find that the amount of the crop, its size or weight, and its value, increase in proportion as the soil is well-drained, well-tilled, well-cleaned, and well-fertilized. If we neglect or decrease the draining and cultivating, the cleaning and the enriching, we know the crop will grow less year by year. When the trees were first cut down and the fields partially cleared large crops were grown; the soil was new (virgin soil as we say); it contained a large amount of leaf mold that had been accumulating for centuries. On many farms larger crops were once grown among the stumps than are now grown on the cleared field. Then the stumps were burned out, and the ashes, rich in potash and lime, further improved the soil. In some cases the fields have been well-drained and well-cultivated, and year by year the fields have been fertilized or manured. Such farms are still very productive. But we all know what are called run-down farms, that will not now produce heavy crops of grain or hay; they were once the same as the first-class farms, they had the same start. Why the change? Year after year hay and

The subsoiler following the plow. Lowering the water reservoir.

grain were grown and taken away from the soil and nothing was put back. These crops took up the plant food out of the soil. The rich soil has become poor. If you put a thousand dollars in the bank and then begin to draw out a hundred dollars every year and put nothing in, you will one day use up all of your money—your bank account will become less and less, and you will become poor. So with the soil. There is a limited amount of plant food in the soil, and even though you drain and work it well, if year by year you take away from it and put nothing back your soil will in time become poor. Some soils are richer than others and therefore will not become run down so soon. Now let us consider the method of preventing good soils from becoming poor and of making poor soils richer.

Fallowing the Soil.—In former years, before the great prairies were open to settlers, the farmers of Ontario and the Eastern States grew wheat as their principal market crop. Its price in many years was more than one dollar a bushel. The usual practice was to prepare the land for fall wheat by a *bare fallow.* The soil was allowed to lie idle or unproductive for the whole or the greater part of the season preceding the sowing. It was plowed from time to time and harrowed. What benefit did that tilling bring? The rains fell and washed down a little material out of the air. This will be seen if you contrast rain water with clear spring water—the former has been changed, something has been taken out of it by the soil, and something else given to it by the soil. The soil is benefited by rain water passing through it. Then some ammonia might get into the soil from the air. Nothing of a solid mineral nature, however, such as potash, or soda, or lime, or phosphates could get into the soil from the air, simply because they are not found in the air. But one thing could be done and that was done, namely, the air could get into and through the soil and help weather it and work it over into form available for plant food. Bare fallow, then, does not increase the

material of the soil, it merely works over what is in the soil for feeding the plant; it can not and does not prevent the soil from becoming worked out. Furthermore, there is the loss of one season's crop, and if the soil can be kept in good condition and a crop grown at the same time, all will admit that the latter should be done. In bare fallowing, however, the soil is more or less cleared from weeds when the fallowing is thoroughly done. But weeds can be cleared out by other means than the bare fallow. First of all a cultivated crop can be grown, such as corn or roots—the constant cultivating required during early growth will clear out the weeds. Or a crop can be put in that grows quickly and that covers the ground well, such as clover, buckwheat, etc. This smothers or checks the young weeds, and the green growth can be plowed under to decay and form humus. This practice is called *green-manuring.* In green-manuring there is less water lost by drainage than in bare fallowing and hence less loss of soluble plant food. In addition everything that the plant takes from the air is turned into the soil and the amount of *humus* is thereby increased. This latter result is very beneficial in loosening up heavy soils and in making light sandy soils more loamy.

Fertilizing the Soil.—The plant gets some food out of the air through its green leaves; the water comes from the rains that fall on the soil and pass in through the roots; the mineral matter or ash comes only from the soil, passing into the plant through the roots along with the water. The air is free for all and is about the same everywhere. The rains and snows are largely beyond the control of man, except as affected by the cutting away or growing of trees, the drainage of the land, and its proper cultivation. But as for the soil food, the mineral substances, the ash compounds—these must be in the soil, and in such form that plants can take them up, or else no crop will be produced. This soil food is mainly compounds of nitrogen (nitrates, such as saltpetre or nitrate of potash);

compounds of phosphoric acid or phosphates, such as we find in bones; compounds of potash, such as we find in wood ashes; compounds of lime, of iron, of magnesia, etc., etc. Now the point to be noted here is that the plant must have every one of these compounds, and growth will not take place if even only one be lacking. Nearly every soil contains lime; it is a very common substance in rocks and soils, therefore we do not need to supply that food. Magnesia and iron are quite common, and much of either is not required. When we feed the soil, or fertilize it, we have mainly to consider this —whether the soil needs nitrogen, phosphates, or potash. These are the three main constituents of fertilizers, and they largely fix the values of those that are applied.

When we apply barnyard manure to a soil, we add a bulky fertilizer that, in addition to increasing the plant food, has an important effect upon the texture of the soil. For instance, light, sandy soils are apt to be poor in plant food, and to be too loose or porous—the rain runs through them. You notice that as the barnyard manure becomes older in the pile it becomes darker through changes that we call fermentation. This dark color is due to the changing of the straw or litter into *humus;* and when this is applied to the light soil the texture of the soil is improved, the sandy soil becomes more loamy. When applied to clay soil its sticky quality is more or less overcome, and the heavy clay changes towards a loose loam. One of the main benefits of applying barnyard manure to a soil, then, lies in its effect upon the texture or physical quality of the soil. This same effect is produced by green manuring, that is the plowing under of a green growing crop such as clover, tares, rye, or buckwheat

The barnyard manure contains compounds of nitrogen, of potash, and also phosphates, so that in it we apply the different kinds of food that plants must get out of the soil. Barnyard manure is called a general or complete fertilizer.

Soils differ as to their composition; some, such as mucky soils, may contain plenty of nitrogen but not enough phosphate or potash. In this case the use of a phosphate such as ground bone, or of potash such as wood ashes, would change a barren soil into a fertile soil. Such a soil as a light-colored clay may require nitrogen compounds to make it complete.

Again, a soil may contain plenty of food, but it is locked up, it is unavailable; that is, it is not soluble or in form ready to be taken up by the plants. If we drain and cultivate it so that the air can get in, these will in time be changed into soluble forms. But sometimes we can hurry up or assist in this work, as when we apply land plaster (sulphate of lime) to a soil bearing clover, salt to a root crop or to grain, and quicklime to to a heavy clay or to a fresh mucky soil. The plaster, salt, and lime are not direct foods, but they act upon the constituents of the soil, setting free potash and nitrogen compounds.

Nitrification.—Wheat and other cereals take up their nitrogen from the soil in the form of nitrates. These are sometimes supplied in fertilizers in the form of nitrate of soda. Nitrate of potash, or saltpetre, is now too expensive to be so used. Humus contains nitrogen, and in its decay forms nitrates, especially nitrate of lime. The change from the insoluble forms of nitrogen in humus to the soluble nitrates is brought about by ferments. These are minute forms of plant life too small to be seen by the eye. Yeast that is used in fermenting dough is a ferment somewhat similar. In order to do their work, these tiny nitrate ferments in the soil require warmth, air, and moisture. Humus, of course, must be present. If the soil is sour, they will not work. Good drainage and tillage, therefore, assist. The fermentation of the manure pile in the barnyard is brought about by ferments. Green-manuring adds material for making nitrates, and barnyard manure adds not only humus but also the ferments. The making of nitrates in the soil is called *nitrification.*

The leaching of manure. This pond has been produced by leaching and drainage from the pile of manure upon its farther side.

CONCLUSIONS :—

1. All of our soils were once fresh, unworked, virgin soil. In many cases worn-out soils were once very rich ; they have been made poor by over-cropping and little fertilizing.

2. Many soils have but a small amount of mineral food in a soluble or available form.

3. Bare fallowing is for the purpose of working over the hard, rocky, insoluble portion of the soil into soluble form. This is done by frequent plowing and harrowing, thereby letting the air in. Weeds also are sprouted and afterwards killed.

4. Green-manuring has the same effect, but prevents loss of food through drainage, and increases the humus of the soil.

5. The three substances that are most deficient in the soil are nitrogen compounds, phosphates, and potash.

6. The value of a fertilizer consists not only in the amount of these three substances, but also in their state of solubility.

7. Nitrogen is found in nitrate of soda, sulphate of ammonia, dried blood, guano, fish refuse, etc.; phosphates in bone manures and rock phosphates ; potash in wood ashes and potash salts.

8. Barnyard manure is a general fertilizer supplying all three constituents. Its value consists largely in its *humus.*

9. Quicklime, land plaster or gypsum, and salt are valuable as fertilizers, not because they contain plant food, but because they act upon the soil, setting free insoluble plant food.

10. Draining, tilling, and airing the soil are necessary for the nitrification of humus, or the making of nitrates in the soil.

SUGGESTIVE :—

Moisture is necessary for the speedy decomposition of green crops when plowed under. Might a soil be injured for a while by turning under a crop of rye during a dry time ?

We have seen that fertilizers must be dissolved before they can be taken up by the plant. What is the effect of pouring water over a pile of manure ? Does not this leaching lessen the value of the manure ? Is it not desirable, therefore, to prevent this loss by providing a cover for the manure pile ? This liquid fertilizer is very valuable.

PART III.

CHAPTER XI.

THE GRASSES.

Nature of Grasses.—If we carefully lift a slice of green growing sod, we find it is made up of a mat of grass plants. We pull these apart, and find that the roots are all fibrous. If we pull up a wheat plant, we find it also has a fibrous root. So has corn. So has timothy. Next take a stalk of timothy. It is round and smooth on the outside. Cut it open. It is full of narrow tubes running up and down. There are some hard joints in the stem. In the case of a wheat straw you find the stem hollow, except at these joints. Now observe the leaves of the green timothy. They are long and narrow in the blade. Pull this blade and you find that where it meets the stem it is wrapped around it, forming what is called the sheath. The sheath is split down one side and is attached to the stem at one of the joints. Further, notice the little growth on the leaf called a " ligule." The leaf then consists of three parts—the blade, the sheath, and the ligule. From the structure of the stem and the form of the leaf you can always tell a true grass from other plants, such as the sedges.

By comparing the following plants you will observe that they have the same kind of stems and leaves, and therefore they are all members of the grass family *(gramineæ)*:—the common grasses of the fields, such as timothy, orchard grass, June grass, fescue; grain-producing crops such as wheat, oats, rye, barley, corn, millet; sugar-producing crops such as sugar-cane and sorghum.

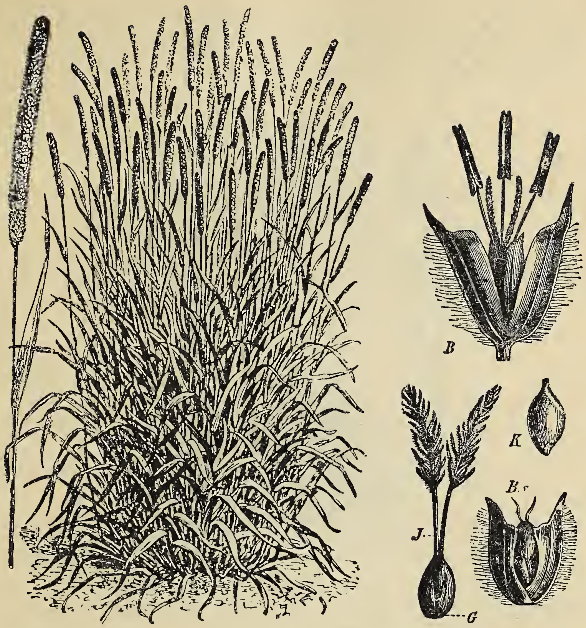


Fig. 20.—Timothy, also called Herds Grass, a typical hay grass. Figures on right show the blossoming. *B* is a single spikelet taken from a head or spike. It shows the three stamens and the two stigmas of the pistil. In a blossoming head of timothy these stamens may be seen hanging loose. *G* is the ovary with two slender styles, *J*, and two feathered stigmas—the pistils of the blossom. *B r* is the matured or ripened spikelet with seed inside; *K* is the seed.

When a grass plant grows tall and produces seed or grain large enough to use as food, we allow it to ripen its seed. We use the seed as grain and the leaf and stem we call straw.

When a grass plant grows tall, but produces very small seed, we generally cut it down before it produces seed. We then call this hay. Such grasses are timothy, red-top, orchard grass, the fescues, the foxtails, brome grass, and rye grass.

When a grass plant does not grow tall, but grows short and thick, we use such plants for pasture grasses. Such grasses are June grass and Canadian blue grass.

Fig. 21.—Kentucky blue grass or June grass. A pasture and lawn grass.

The best way to study the different grasses is to study them as they are growing; you will then find out how many there are and how different they are in form of leaf and head, in color, and in their habits of growing.

BLOSSOMING OF GRASSES.—There is one other point to study in grasses, and that is their blossoming. The blossoming of the corn plant will be referred to in the next chapter. The blossoms of wheat and oats are much like those of timothy, shown in fig. 20. The grass blossoms, generally, are very small and are not very bright in color, we are therefore likely to overlook them; but every grass plant blossoms before it forms seed. If we allow the timothy to stand too long before

cutting it becomes woody; but dusty hay is caused by the pollen from the blossoms on the head. Notice, also, that all the blossoms on the timothy head do not come out at the

Fig. 22.—Illustration showing how some plants reproduce by creeping roots. 1, new plant just coming up; 2, plant before blossoming; 3, old plant forming seed. June grass and couch grass spread in this way.

same time. Some are a little later than others. Because of this we sometimes hear it said that it blossoms twice, but this is not the case. Grasses for hay are generally cut just after blossoming, or just as the seeds begin to form.

Clover and buckwheat are not true grasses. Why not?

Why are foxtail and red-top so called?

Which grasses have branched tops and which spikes?

What is meant by "seeding-down"? When is this done. Why does not the grass outgrow the grain?

Explain why grasses, such as June grass, are so common. Why do not wheat and corn spread?

CHAPTER XII.

THE GRAIN CROPS OR CEREALS.

The principal grain crops of the farm are wheat, oats, barley, rye, corn, buckwheat, and millet, and to these we shall briefly refer. It must be remembered that these crops also may be, and frequently are, cut green and fed to stock before the grain is formed, especially rye, corn and millet. Other crops also are used for soiling, such as clover, peas, and tares or vetches.

While the plant is growing it takes in food from the air and the soil. It keeps on increasing in size until in full bloom. Then the seed begins to form from the blossom, and all the material that goes to form the seed is taken up out of the leaf, stem, and root, where it has been stored up. During all this time of seed-forming, very little plant food comes in through the root, so that when the seed is fully formed, the leaves and stalk and root are not so rich or nutritious as they were at the time of blossoming. From this you will see why it is that straw is not so rich a food as hay.

WHEAT.—Wheat is sometimes classed according to its color, red and white; sometimes according to its grain, hard and soft; sometimes according to its chaff, bearded and bald; sometimes according to the time it is sown, fall or winter, and spring. We use these four methods in describing any variety of wheat. Where the first wheat came from we do not know; but wheat taken from one climate to another and from one kind of soil to another will change in size, form, and general appearance, so that we need not expect to find the same variety of wheat always appearing exactly as described.

This we should remember, that wheat, like every other kind of grain, must be carefully selected if we wish to keep it improved. We can even change a winter variety to a spring by sowing gradually earlier year by year; and we can change a spring variety to a fall variety by sowing gradually later year by year.

Get a head of bearded wheat; take it to pieces, and observe the long beards, what they are and how attached. Compare with the beards of a barley head. Are the beards on the grain?

The grain of wheat is made up of several parts, the three principal parts being—first the outer skin or the bran coatings, second the white flour portion, and third the little yellow germ at one end. This germ is the living part of the grain, the flour is the food stored up for feeding it in its early growth, and the bran is the covering or cloak. If we grind up the whole grain we get whole-wheat flour. By the old stone milling process the bran alone was separated from the rest. By the new process the grain is divided mainly into three parts, namely the bran, the white flour, and the bluish or greyish germ flour.

Place several grains of wheat in your mouth and chew them. Gradually you separate and swallow part of the wheat—that is the starch; you will have left in your mouth a gummy substance— that is the gluten. The gluten is the richest part of the flour; it is what gives it its strength.

RYE.—In some countries of Europe rye takes the same place that wheat does in America, it is the great flour-producing crop. As with wheat it is sown both in the fall and in the spring. It is very hardy and can be grown even on very poor soils. With us it is sometimes sown in the fall to be cut early in the summer as a soiling crop. The grain is longer than that of wheat and its flour is quite dark.

OATS.—The oat plant furnishes a most important food for man as well as for horses and other animals. Oats are generally classed according to their color. The head is branched and the grains are covered with a coarse loose husk, hence its light weight.

This grain will grow in poorer soil than wheat and much further north. It is a rather hearty and gross feeder and produces very large crops on rich soil.

Barley.—This grain is classed as two-rowed, four-rowed and six-rowed, according to the number of rows of kernels in the head. The two-rowed requires a longer season of growth than the six-rowed, which is one of the most rapidly growing and maturing grains that we have. Barley is used as a food for stock, and also for the making of malt out of which beer is brewed. Its value for malting depends upon the soil and climate. It must be of bright color, well filled, and all ripened so that it will sprout evenly in malting.

Corn or Maize.—In Great Britain the name corn is applied to either wheat or any bread-producing cereal, in North America it means Indian corn or Maize. The distinction is made of sweet corn which is used for food by man, and common corn, which again is divided into flint and dent. Flint corn has a hard flinty kernel, and dent has the indented form on the tip of the grain. The roots are long and therefore the plant feeds quite deeply and requires a soil of deep cultivation. It has long heavy leaves and thick stalks, not hollow like the previous grains, but more or less filled. It bears heavy ears and produces large quantities of food per acre. We at once conclude that it takes much more food from the soil than the others, that it is a heavy feeder and requires heavy manuring. When well cultivated, it is a good cleaning crop.

The blossoming of the corn is worth noticing. Fine silky threads may be seen hanging from the end of the green ear, all attached to the cob—these are the "styles," the female portion of the blossom. At the top of the stalk is "the tassel" which carries the stamens or male portion of the blossom. The pollen from these falls down upon the pistils of the ear and there completes the blossoming. If different varieties of corn are planted near together the pollen from the tassels of one variety

may be carried by the wind or by insects to the silky pistils of another, and thus produce the peculiar kernels that are sometimes seen on ears of corn. In growing corn for seed, therefore, it is necessary to grow each kind by itself, far from any other variety.

There are various ways of growing corn. It may be sown broadcast, when the plants grow close together and cover the entire soil. In this case the plants do not have sunlight upon the lower leaves and the stalks, and as a result the plants do not mature, and production of ears is prevented. The crop consists entirely of leaf and stalk, and is cut and used just as we cut and use timothy hay. The effect of the lack of sunlight is seen also in the pale yellow color of the under leaves. The stalks and the leaves are quite watery, and the amount of food per acre is less than is got by the other methods. If ears are desired the corn must be sown in rows or in hills far apart; the taller the corn the farther apart must be the drills or hills. A method adopted by many western corn-raisers is that known as "listing." The corn is grown in furrows, which are gradually filled in as the corn grows higher. Just above the surface of the soil a ring of suckers shoots out from near the joint or node, and as the earth comes up to them these take root. In this way the corn becomes deep rooted, is held firmly in place and is able to withstand drouth.

A great deal of valuable information can be learned by carefully watching the growth of different kinds of corn in the field. From what part of the stalk do the ears grow? What is the effect of cutting off part of the tassels? What is the effect of cutting off all the tassels? What is the effect of removing the smaller ears and leaving only the larger? What is the effect of cutting away all the corn for about eight feet on every side of a single hill or stand?

Sugar Cane.—This plant, like corn, has a stalk whose tubes are filled with a juice rich in sugar. New plants are started

from "cuttings." Its stalks grow from one to two inches thick and from eight to twenty feet high. It is cut before flowering and the juice pressed out. This juice is evaporated and a dark brown sugar remains, from which the white sugar is got by "refining."

SORGHUM.—This has pithy stalks like maize and sugar cane. There are several varieties of it, one, Indian Millet or doorha, is grown extensively in Eastern countries for its grain for bread making; another is grown for its sugar or syrup, also as food for stock; and still another (broom corn) for its tassels, out of which the whisks of brooms are made. The broom-corn tops are cut off while still slightly green and are dried in dark buildings, where they partially bleach out.

These three members of the grass family, maize, sugar cane and sorghum, are then distinguished from the other grasses, in having their stalks filled, and all contain a considerable quantity of sugar in their juices. Sugar cane grows only in very warm climates, sorghum is found farther north, and maize, although originating in Mexico or Central America, will, in some of its varieties, mature its grains much farther north.

RICE.—This is the great bread food of China and Japan, and is best grown in lands that are mild in climate and are capable of irrigation. The land is prepared as for grain. The rice is sown in drills and covered with about two inches of soil. Then the water is let on to a depth of 12 to 18 inches. After standing for four to six days it is drawn off and the plants allowed to get a good start; water is again let in for a time and then drawn off before harvesting. The growing of rice upon wet soils gives us the explanation for the scriptural teaching: "Cast thy bread upon the waters, for thou shalt find it after many days." (Eccl. xi. 1.)

CHAPTER XIII.

THE LEGUMINOUS PLANTS.

Nature of Legumes.—Plants such as wheat and barley were formerly cut with a sickle; the pods of such as peas and beans were gathered by hand; hence the latter were known as *legumes*, from the Latin *lego*, "I gather." All plants resembling peas and beans in their botanical nature were called the leguminous plants. They were also called *pulse* because, as some say, of their being pulled or plucked. The most striking resemblance is in the blossom. The seeds are formed in pods

Fig. 23.—Blossom of a legume as of pea, bean, or flowering locust tree.

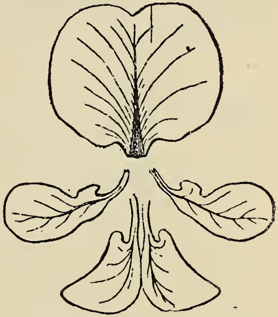


Fig. 24.—Blossom of legume taken apart, showing five leaves of corolla. Upper large leaf is the "standard," the two lower the "keel," the two side the "wings." The pistils and stamens are enclosed in the keel leaves.

Fig. 24.

or legumes of different shapes in different plants. In some of the members of the leguminous family, the blossoms and pods are too small for us to observe readily their resemblance to those of the pea and bean; but a careful study of the roots, leaves, and blossoms of the following plants will soon prove that they are all quite alike. They are all legumes with which we should be familiar.

Leguminous Family (*Leguminosæ*).

Common pea.
Common string bean,
Lima bean,
Horse or Windsor bean,
Common vetch or tare,
Common lentil,
Lupines,
Common red clover,
White or Dutch clover,
Alsike or Swedish clover,
Crimson or scarlet clover,
Mammoth red clover,
Lucerne or alfalfa,
Peanut or ground nut.

From this list of plants we see that the family is large and important. In addition there are many weeds belonging to this same family. To speak of clovers as being grasses is botanically incorrect, since in form or shape and in mode of growth they are entirely different. The most noticeable difference is in the shape of blossoms. The leaves also are different in shape and in arrangement. Contrast a plant of clover with a plant of timothy or wheat. The stalks also are different, and the roots are quite different. Pull up a large red clover or pea plant, and also a wheat plant, and contrast their roots. Which is the more fibrous and matted? The clovers send their roots deeper into the soil. Observe, also, the little knots, or balls, or tubercles on the clover roots. These tubercles play a very important part in the nourishment of the leguminous plants. They are filled with many little living parasites, something like yeast cells, that grow and feed upon the free nitrogen of the air, from it forming compounds that help to nourish the plants. Now we have already mentioned

Fig. 25.—Root of a legume showing knots or nodules or tubercles.

that wheat, for instance, will readily feed upon nitrogen in the form of nitrates; but if we apply nitrates to clover no effect is produced. The wheat cannot take up the free nitrogen of the air, but the clover can, through these root tubercles. Sometimes clover does not grow well; and when pulled up very few, if any, of these little tubercles are found upon the roots. If, however, some soil in which clover has been growing well, or the washing from such soil, is applied to the weak clover, the plants soon begin to thrive and the tubercles are seen growing upon the roots. These tubercles possess the power of taking up free nitrogen from the air in the soil. If we can get leguminous plants to grow in a poor soil and then turn them under, they will decay and produce humus rich in nitrogen that will give rise to nitrates (by nitrification) for the benefit of the wheat or other grain crop that comes after. The seeds from all leguminous plants are very rich. Then we can state the following as the valuable points in connection with leguminous plants:—

1. They have many leaves and are good for fodder.
2. Their seeds are very rich in food material.
3. Their roots are generally long, therefore deep feeders.
4. They take up free nitrogen from the air, and are therefore easier on the soil than are cereals or root crops.

Peas are generally grown for the seed, which is very rich in nitrogen and in oil. The many varieties grown for man and stock are classed as garden peas and field peas. The straw is richer than that of the grain crops. When grown to be cut green for soiling, peas are generally sown with oats.

Beans are grown in this country for the seed, planted in hills, as a garden crop, or as a field crop with good garden cultivation. Some of the varieties, as the horse bean, require a fairly mild climate. Some are short and bushy, others are tall climbers. Examine their means of climbing.

Vetches or Tares have smaller pods and seeds than peas, and are grown for soiling along with oats. The stiff stalks of the oats help to support the slender vines of the tares.

Common Red Clover is also known as broad leaf clover or trefoil. The peculiar light spot on the leaves and the closeness of the upper leaves to the head are to be noted. It grows to two feet in height, and the roots penetrate the soil deeply. While in some localities it is a perennial, in most temperate regions it is a biennial. Its form and mode of growth adapt it for hay rather than for pasture. It ripens about the same time as orchard grass and about two weeks earlier than timothy. It should be cut before the heads become very brown; if left too late its leaves, which form a large part of it, become brittle and drop off in handling. After being cut once the plants rapidly grow up again, giving a second crop, the aftermath or rowen. The depth to which its roots go depends greatly upon the state of the soil; therefore the soil should be well drained. When the sod is turned over, large quantities of humus, rich in nitrogen, are left near the surface for the wheat or other grain crop following. A variety of red clover is known as mammoth clover.

White or Dutch Clover is a low growing plant, with creeping stems and white blossoms It is very hardy and apt to crowd or smother out other plants. It is one of the most frequent plants in pasture fields, and is especially valuable for sheep and cattle. It is usually sown with grass seeds in permanent pasture mixtures.

Alsike or Swedish Clover is a perennial with pink blossoms, growing about two feet high. It thrives in cool climates. It does not give such heavy yields as red clover, but is specially adapted for hay fields that are to be kept for several years. It is sometimes sown along with other seeds for pastures.

Lucerne "catches" well on sandy loam. This was sown in Ontario, Canada, on July 15th and photographed October 1st of the same year. When plowed down in the spring, much valuable humus is given to the soil. It is also desirable as an orchard-cover crop—that is, a crop which will protect the roots of the trees from frost during winter and add nitrogen when plowed down.

Crimson or Scarlet Clover grows further south than the others, has a long scarlet head and makes an early rapid growth even on poor land. It is a hay plant. In some places it is used as a "catch crop," that is it is grown on land after the removal of grain crops, for a light forage crop or to be plowed under as a green manure.

Lupines include a number of little shrubby plants that bear very showy flowers. The plants are apt to be too woody for forage, but sheep readily eat them. Their principal use in this country is for plowing under as green manure, since being leguminous they gather nitrogen from the air. The most common are white, yellow, and blue lupines.

Lucerne or Alfalfa is a plant resembling clover in its growth. It is not strictly a clover, although sometimes called Spanish clover. It is difficult to start upon land, but once well started it is long continued, being a deep-rooted perennial. It has a smaller leaf than clover and a purple head, more open. It is somewhat bushy and sends its roots as deep into the soil as the water level will allow. For this reason it resists drouth. It must be cut early or it will produce a very coarse woody hay. In mild climates it may be cut for hay several times during the year.

The Peanut is an annual, growing in warm climates on light soil. Other names for the plant are earth-nut, ground-nut, goober. Though not a nut its pod is somewhat like a nut and it belongs to the pea family. The seeds are very oily, giving an oil used for soap making.

CHAPTER XIV.

ROOT CROPS AND TUBERS.

Nature and Growth of Roots.—If we place some seed of the turnip or beet in the ground in early summer, we find a plant sprouting up that has broad thick leaves. The root is tapering, sometimes quite long, and has fine rootlets growing on the sides. Towards the end of the season the leaves wither, change color, and die. When we pull up the root we find a thick mass of juicy substance that is relished much by animals. This turnip or beet root has not finished its life-work as a plant, since it has not yet produced any seed or any new plants like itself. If we leave it in the ground, or if we take good care of it through the winter so as to keep it cool and unbruised, and plant it in the early summer, it will begin to grow again. A new growth will appear above the soil, a stalk will be formed and seed be produced of the same kind as that which we sowed in the first place. If we again pull up the plant, we find the thick fleshy root has become very thin and fibrous, and is of no use as food for stock. We conclude that these plants are *biennials;* that during the first season they store up large quantities of food in their root, and that this food in the root nourishes the plant during the second season. Since they have a whole season to gather food, we find that the weight per acre greatly exceeds that of many crops that are annuals, and they take a large quantity of material out of the soil. These plants are heavy feeders. By keeping the soil well cultivated we destroy the weeds, keep the soil moist, and help the action of the roots. The roots are very watery and contain large quantities of the substances that are

first formed in plants, namely sugar and starch. The materials that are taken from the soil through the roots, and that which passes in from the air, are worked over in the green leaves, so that while green we would expect to find a considerable quantity of mineral or soil material in the leaves. Any green leaves that are cut from the roots when they are pulled, therefore, should be left on the soil where the roots grew, so as to help keep up the richness of the soil. The roots keep on growing during the fall until the weather becomes very cold, therefore they have a good chance to benefit by the nitrates that are formed during the latter part of summer. They have the advantage of spring-sown grain crops in this regard. Since root crops are such heavy feeders, and since the ground should be kept thoroughly cultivated during their growth, they are generally used as the crop to which the largest quantity of barnyard manure is applied. In addition to heavy manuring, another very important necessity is thorough cultivation of the soil before the sowing of the seed. The root is thick and compact; it has to push down and out on all sides. If it cannot go straight down it will twist about or push itself partly out of the ground. For well shapen and perfect roots, then, we must have a well-tilled and well-drained soil.

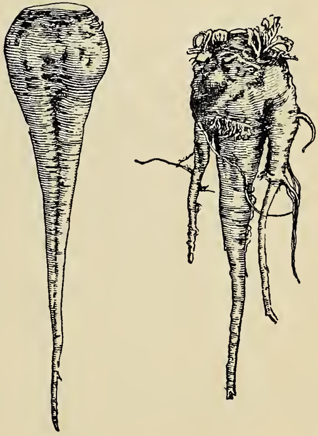


Fig. 26.—Sugar beet on left grown in good soil, well drained and well cultivated; beet on right grown in rough soil.

The Turnip belongs to what is known as the mustard family (*Cruciferæ*). The principal members of this family are the turnip, the radish, the cabbage, rape, cultivated mustard, horseradish; the weeds, wild mustard or charlock, shepherd's purse, and wild flax; the flowers, stocks and candy tuft. The flowers of all these plants have 4 petals spread out in the shape of a cross—hence the name, *cruciferæ*.

The Carrot is a plant whose varieties differ greatly in shape, size, and color. Celery and the parsnip belong to the same family. The blossom resembles the stays of an umbrella; hence the name—*umbelliferæ*—applied to this family. The shape of the root, differing from that of the turnip, suggests that the plant goes deep and therefore requires a soil loose and open and deeply cultivated.

The Beet belongs to still another family, the goose-foot family. The original of this root was a wild plant of Southern Europe. Gradually it has been improved, the root has been enlarged and the composition changed, until now we have several very valuable plants whose roots are widely used. The mangel-wurzel or mangel is one variety, grown for stock feeding. The sugar beet is another, grown for its sugar. Mangels when grown on rich, well-cultivated soils produce enormous yields per acre. They may be kept stored for late feeding.

The sugar beet is a good example of what can be done by way of improving plants. In its wild state the beet had very little sugar that could be extracted. By cultivation it was found that the quantity of sugar increased. Suppose we take a field of common white beets and select the most perfectly shaped roots of about 1½ or 2 pounds each, and plant them and then select the best seed from these and sow this seed. We pick out the best beets from that crop. Then by testing small pieces of the roots we find out which have the largest amount of sugar, and plant them. We keep on in this way for several years; we find that at last we get seed that will produce beets

that are clear-skinned, nicely tapering, having a large amount of sugar and a small amount of ash material. We could thus develop beets good for sugar making, whose nature it is to produce sugar. In this way the sugar beets have been developed, and in this way the seedsmen are still producing improved seed. To grow good sugar beets the soil must be well-drained and well-tilled, the plants must be grown closer together than when grown for feeding stock, and the roots must be kept well covered, since the sugar is stored in the part under the soil. Any green collar on the beets will, like the green leaf, have too much mineral matter. The beets are taken to the factory, cleaned, pulped fine, the juice extracted, and the sugar obtained from it by evaporation. Sugar, like butter, is made up from carbon, hydrogen, and oxygen, which come from the air and the rain ; so that if the leaves are left in the soil, and the pulp taken back and fed on the farm there is little or nothing lost from the soil.

The Potato is here included among the roots, and yet we all know it is quite different in form and growth from the beet and the carrot. We do not sow seeds, but potatoes or parts of potatoes ; the method of growth under ground is peculiar ; and the branching tops and blossoms are quite different from those of the roots. If we examine a potato tuber we find upon it many eyes or buds. If we place the potato in a warm damp room these buds grow out into green stems. We can even cut it into many pieces and still the eyes will send out stems. We do not cut up roots for planting ; we sow their seed. If we pull up a hill of young potatoes we find what appear to be two sets of roots, one having little balls upon them, the other none. Trace those that carry the little potatoes back to the stem and you find that they are really branches of the stem, whereas the others are the true roots. Then we conclude that the potatoes grow on underground stems, that they are really swellings of the stem and the

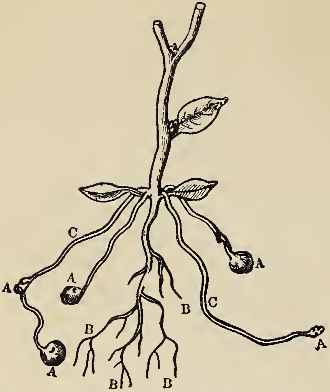


Fig. 27.—Potato plant, showing *B* the true roots; *C*, the underground stems; *A*, the tubers, which are swollen or enlarged parts of the stems. The eyes in the potato tubers, therefore, are buds.

eyes are buds; so that what we plant are cuttings of the underground stems of the plants. Observe the arrangement of the eyes in the potato. Rightly, then, we speak of the potatoes as being tubers not roots. Jerusalem artichokes also are tubers.

If you cut open a potato you find it filled with a starchy substance generally white in color. If you cut up fine a sugar beet and place it in a coarse towel you can wring the juice out of it quite easily, you cannot easily do so with potatoes. You conclude that potatoes have less water and more dry matter or food in them than have the roots. If you evaporate the juice from potatoes you find little or no sugar. Then we conclude that roots have large quantities of sugar and water in their make-up, but potatoes have less water and quite a large amount of starch.

The potato, the tomato, and tobacco belong to the family known as *Solanaceæ*. The sweet potato is the root of a plant grown in very warm climates, and belongs to the family *Convolvulaceæ*, as do the morning glory and dodder.

New varieties of potatoes may be got by sowing the seed and selecting the best tubers so grown, planting these and selecting the best grown from them, and so continuing.

CHAPTER XV.

VARIOUS OTHER CROPS.

BUCKWHEAT produces seeds or grains which resemble in shape small beech-nuts, hence the name beech-wheat or buckwheat. The second part of the word would suggest that it is a kind of wheat or a member of the grass family. This is not the case, as the leaves and flowers prove. It belongs to the family known as the *polygonaceæ*, to which also belong rhubarb, the docks or sorrels, and knot grass. Its roots are quite short and it feeds largely on the air. It will grow even on very poor soils, where it is sometimes plowed under as green manure. Its peculiar blossom is noticeable in its color and odor, and is much sought by bees for its nectar. The grain is used for flour and also for feeding in moderate quantities to stock. Buckwheat flour is not so rich in nitrogen as that of wheat, and the straw has more fibre than the straw of the *gramineæ* or true grasses.

THE SUNFLOWER is an annual, growing very high on tough stalks with a large showy head filled with seeds. These seeds are rich in oil and nitrogen compounds. The oil forms nearly one-fifth of the dried seed, and is extracted for various uses. The seeds are used also for feeding stock. Why is the plant called the sunflower? The sunflower is a fine example of the large family known as the *compositæ*, which have many flowers in a single head. The thistle, ragweed, goldenrod, aster, daisy, yarrow, chrysanthemum, marigold, salsify, dandelion, lettuce, and sunflower are all members of this family. Compare the heads of any of these before and after seed formation.

Rape has already been referred to as being closely related to the turnip and cabbage. Its leaf resembles that of the turnip, but its root is much smaller and its top much larger. It grows to a height of from one to three feet. Some varieties are annuals and some are biennials. It is grown both for its seed, which contains a large quantity of valuable oil—rapeseed oil—and also for its tops, which are used in pasturing and in soiling. When used for soiling or pasturing, the biennial is sown in drills and cultivated.

Flax is an annual with slender stems about two feet in length and bearing bluish flowers. The seed is known as flaxseed or linseed. The word linseed is from the botanical name *linum*, which is also found in linen, the cloth made from the flax fibre. It is grown both for its seeds and for its fibre. The seeds contain a very large amount of oil (linseed oil), which is very valuable for paints and other purposes; also a large amount of nitrogenous compounds, and of ash material. When the oil is removed the bye-product forms one of the richest foods used for stock-feeding. When the plant is grown for fibre it may be pulled at any time after blossoming. The fibre is obtained from the stalks. We have before referred to the cell-structure of plants. When we cut across a piece of wood we cut across its cell tubes; when we cut lengthwise along the wood we cut these tubes from one another. The grain, as we say, runs along the stem or limb. In some plants these cells are strung together in threads and are very tough so that they will hold together. The cells in the bark or bast are generally longer and tougher than those in the wood, and are known as bast cells or bast fibres. The inner bark of bass wood (or bast-wood) is quite tough because of these. These bast cells in the flax are very fine and very tough, and, therefore, make fine fibre. The best fibre is got from flax that has not ripened its seed-vessels or bolls. Why? Generally, however, the plant is allowed to ripen its seeds. The plants are

pulled by hand, dried, and tied in bundles. The seed is separated by what is known as "rippling" or combing out. Then the straw is partly rotted, either on the grass or by steeping in vats of water. This process rots the coarse woody part of the stem, and separates the fine fibre from it. It is then dried and "scutched," either by hand or by machine. This process of scutching simply rubs or beats away the loose woody parts from the long fibres. The fibre is now ready for use, to be made into twine or thread or linen cloth. To grow good crops of flax, rich, clean, well-drained, well-cultivated soil is needed. It requires a moist climate, moderately warm. The plant is very rich in nitrogen, potash, and phosphoric acid, and therefore we may conclude that it takes a good deal of nourishment out of the soil; but these constituents are found almost wholly in the seed and straw and not in the fibre, so that if the straw is returned to the soil, and the seed fed on the farm, there will be little loss in growing flax for the sale of fibre only.

The Hop is a member of the nettle family. It is a perennial plant. It is started by cuttings, in hills about six feet apart. The plants are not woody enough to support themselves, and therefore climb up to the air and sunshine by twining. The hop blossoms are picked by hand when just ripe (a condition learned only by experience), and dried in a kiln or drying house (called an oast house in Kent, England), when they are packed and sold for use in brewing. The value of the hop is greatly influenced by the climate. Hop vines always twine in the same direction—to the right. Bindweed and morning glory twine to the left. How do the grape vine and Virginia creeper climb and support themselves? How do peas and tares?

We have already learned that the two important parts of a blossom are the pistils and stamens, that perfect blossoms have both, but that in some plants there are blossoms having pistils but no stamens; and in other plants there are blossoms having stamens but no pistils. The former blossoms are

called *pistillate* blossoms, and the latter *staminate.* Only the pistillate blossoms form seed. In some cases pistillate and staminate blossoms grow on the same plant, as in cucumber vines. These are said to be *monœcious* plants. In other cases the pistillate and the staminate blossoms grow on different plants. These plants are said to be *diœcious.* The hop plant is *diœcious.* In setting out a hop-yard, therefore, it is necessary to have here and there some plants that produce staminate blossoms, to supply pollen for the pistillate.

TOBACCO is an annual, grown only in warm climates, but much farther north than cotton, being grown in the milder parts of Quebec and Ontario. It is grown for its long, broad leaves. In the use of tobacco we observe three things; first, it burns readily; second, it gives a very large amount of ash; third, it has a peculiar effect upon the smoker. It burns readily because, in addition to its woody or fibrous matter, it contains large quantities of potash, which readily unites with the oxygen of the air. Its ash forms from 15 to 20 per cent. of the entire plant. Its effects upon the human system are due to a compound known as *nicotine*, similar to *theine* in tea and *caffeine* in coffee. In their pure condition these "alkaloids" as they are called, are poisons.

From the following statement it will be seen that tobacco is very hard upon the soil, and requires very rich fertilizing. An acre of tobacco will yield about 1,500 pounds of tobacco leaf. The whole crop will contain about 70 pounds of nitrogen, 15 pounds of phosphoric acid (in phosphates), and 150 pounds of potash—235 pounds in all. An acre of wheat, yielding 20 bushels of grain, will contain 40 pounds of nitrogen, 15 pounds of phosphoric acid, and 18 pounds of potash — 73 pounds in all. An acre of meadow hay, yielding 2 tons, will contain about 56 pounds of nitrogen, 14 pounds of phosphoric acid, and 60 pounds of potash—130 pounds in all.

CHAPTER XVI.

WEEDS.

"A weed is a plant in the wrong place: it is a plant that takes possession of the soil against the farmer's will, and to his detriment."

WEEDS ARE PLANTS.—White clover is frequently sown with grass seed on lawns, yet a few plants in a fine lawn of June grass would be considered weeds. Tares are grown as a fodder crop; in a wheat field we call them weeds. Ox-eye Daisies and Goldenrod in a flower garden are fine plants, but in pastures or hay fields they are weeds. A weed is a plant just as much as wheat, corn, or clover. It has all the parts of plants, grows like other plants, and forms new plants. But it is a plant that we do not want; it is a plant out of its place, or, rather, it is a plant in the wrong place.

ORIGIN OF WEEDS.—Weed-seeds are derived from a foreign and also from a native source. The former find a ready means of conveyance in immigrants' effects, and likewise, from seeds and trees imported for experimental purposes. In the latter case too much caution cannot be observed, especially where the importation is from a country similar to our own in climatic conditions. Seeds indigenous to the country may find, and in many cases have found in cultivated soil, homes so congenial as to develop them into troublesome pests. Instances of this class are found in Pasture Sage Brush, Sunflowers, Showy Lettuce, and Treach Mustard, so that a sharp look-out

should be kept even upon our own native plants, and no encouragement given them to assert themselves. What we need to comprehend in this connection most of all is, that without some radical mistake in the management of the land, weeds would never have gained their present foothold ; and that all plants settle and thrive best where the competition for life is such that they can enter into it and prosper. But such conditions are not met with in intelligently tilled fields and guarded roadsides.

Objections to Weeds.—We might say that weeds are objected to, because, whether valuable or not in other places or at other times, they are not what we are working for. If a man engaged in moulding ploughshares should find one-half of his work turning out to be large cannon balls he would consider his work, to that extent, a failure, because his business is to make ploughshares, not cannon balls. So if a farmer finds his work resulting half in grain or hay, half in weeds, his work is a failure to that extent. But we must have particulars.

1st. Weeds require some labor, whether we permit them to grow or try to destroy them. Sometimes our labor helps the weeds to grow more rapidly, just because we do not understand their nature. Weeds mean work.

2nd. Weeds, through their roots, take up food from the soil. Our most valuable plants do not take very much out of the soil ; on the average, not more than one-twentieth of their total weight. Usually, however, there is not very much food just ready for the plants to take up. If there are weeds growing with the crops there will be less food for the latter. Some of the weeds are heavy feeders.

3rd. Many weeds have broad, spreading leaves which cover over the tender young plants of our crops, and by

shutting off the sunlight smother them out. These may be seen best in a pasture or on a lawn (Dandelions and Plantains for example).

4th. Weeds draw moisture from the soil through the roots and give it off through the leaves; weeds help to dry up the soil.

5th. Weeds are feeding and breeding grounds for insects, and they assist in the spread of many crop diseases.

6th. Frequently weeds are poisonous to stock, they taint the milk, or they destroy wool.

7th. Weeds offend the eye and degrade the taste for farming.

Because of these facts every weed should be considered an intruder, a thief, and a murderer of other crops, and every farmer should try to keep his soil as clean as possible. To succeed, it will be necessary to know as far as possible the nature and the mode of growth of the weeds.

All engaged in agriculture are fully aware of these particulars, but few seem to realize what they mean in actual cash.

Nature of Weeds.—The destruction of weeds can be successfully accomplished only by a patient and careful study of the conditions of plant life, and the characteristics of the various species that are found troublesome. Only when we understand better the nature and the resources of the Dandelion that has entered and devastated our lawns, can we realize why it has defeated us in our struggle to eradicate it.

Plants are usually classed as to duration into annuals, biennials, and perennials.

Annuals include all plants growing from seed and maturing in one season, provided the seeds germinate in the

spring. These have usually small fibrous roots which seldom penetrate deeply into the soil. They are also capable of producing a large number of seeds. This is nature's safeguard to offset the many vicissitudes which surround annuals. Wild Mustard, Lamb's Quarters, and Wild Buckwheat are examples of this class.

Some annuals, however, under certain circumstances, belong also to the second class, as many seeds germinate in the fall, and the plantlets, being able to endure the winter,complete their growth early in the following season. The StinkWeed and the Shepherd's Purse frequently follow this process.

It is evident, that if the germination of the seeds can be secured under such conditions, the destruction of the plants can be ensured by exposing the delicate roots to sun and wind, by means of harrowing,or by some other method. If all seeds germinated at once this would be an easy task; but, such is not the case, for seeds of this class have often extraordinary vitality, and if too deeply buried will lie dormant for years, only to appear and give an unexpected crop when accident or chance brings them to the surface.

Biennials.—These grow from seed, and require a second year to complete the round of life. All the energies of such plants are, during the first year, centred in collecting and storing up a supply of nourishment, which is used in the course of the second year for the maturing of flowers and seeds. The Wild Parsnip, Blue Burr, Biennial Wormwood, and several others, are members of this class, and their treatment is much the same as in the case of annuals.

Perennials.—These continue growing for several years. They are, therefore, the most dangerous and troublesome, for they are propagated not only by seed, but in most of

the herbaceous varieties by creeping, underground root-stocks, which send up shoots that ultimately form independent plants. The Wild Rose, Couch Grass, Canada Thistle, Perennial Sow Thistle, and some of the Sunflowers, are examples of this feature, while the Plantain, Ox-Eye Daisy, and Dandelion grow but slowly from the root by off-sets. These latter make up for any deficiency, however, in the production of a superabundance of seeds.

In attacking perennials strike at this source of nourishment. If the supply of food be cut off the plants will weaken, other plants will crowd in, and death will follow.

Naming of Weeds.—The weeds are classified like other plants. Frequently, lists of weeds are given, having their common names and also long scientific names, difficult to spell and difficult to pronounce. Why is it necessary to have long scientific names for weeds, when common names are easily pronounced, are easily understood, and are so suggestive? Take an example. Teazel, Water Thistle, Tall Thistle, Indian Thistle, English Thistle, and Fuller's Card are all local names for one weed. All do not know it by the same name, but as *dipsacus sylvestris* every botanist in any part of the world would know it, or would be able to find it in scientific books. Blue Weed, Blue Thistle, Blue Stem, are various names in different places for the same weed. Stick Seed, Stick Weed, Stick Tights, are different weeds, although somewhat similar in name; and Stick Weed, in fact, is applied to different weeds in different places.

The Distribution of Seeds.—The rapid spread of weeds is easily accounted for, when we take into consideration the agencies at work. Everything is in their favor, and nature does the work in many ways.

1. The wind wafts seeds, constructed to float in the air, immense distances, or drives them along the ground with dust or snow; or, in the case of the "tumble weeds," sends the parent plant careering for miles over the prairie, scattering thousands of seeds in its course.

2. Water in creeks and rivers carries them in myriads, and leaves them stranded along broken banks or on flood plains. An illustration of this on a large scale is to be seen near the mouth of the Red River, where hundreds of acres of land have been overrun with Canada thistles, seeded in this manner.

3. Birds and animals help in the distribution. As an evidence of the latter recall the various "tramp burs" that have made use of a cow's tail as a conveyance.

4. They are also distributed by human agency. How? If plants were not scattered in this manner there would be little difficulty in holding them in check.

What are some of the preventives of this promiscuous seeding?

1. Never sow foul seed, even if clean seed should cost double the price.

2. No matter on whose farm a threshing machine has been working, see that it is thoroughly swept down from top to wheels, and run empty for at least five minutes before coming to your farm.

3. Do not thresh in different spots. Have your regular threshing sites, and watch them closely.

4. Clean binders and other implements before moving from foul to clean fields.

5. Fence your farms, and watch the watercourses and the roadsides.

6. Never allow weeds to ripen on your farm; cut them down as soon as they show symptoms of coming to

flower, and encourage your neighbors to take the same precaution.

THE MOST TROUBLESOME WEEDS.—The following weeds are most to be feared. They are given in the order of their aggressiveness.

Tumbling Mustard.
Stink Weed.
Canada Thistle.
Hare's Ear Mustard.
Wild Mustard.
Bird Rape.
False Flax.
Ball Mustard.
Cow Cockle.
Giant Rag Weed.
Showy Lettuce.
Shepherd's Purse.
Pepper Grass.
Wild Oats.
Skunk Tail Grass.

For botanical names and a description of the above and other weeds see the list on page 233.

CHAPTER XVII.

INSECTS OF THE FIELD.

GRASSHOPPERS.—We shall first refer to an insect that attacks nearly all the plants of the field—the grasshopper. You catch one of these insects in the hayfield or the pasture and carefully observe its form. First of all you count its legs—there are six, three on each side. By comparing with other insects you notice that all except spiders have the same number. You observe that its legs are jointed and that its very long hind legs are well suited to jumping or hopping. Then

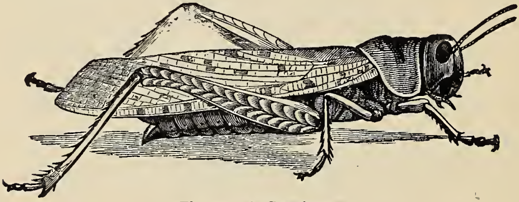


Fig. 28.—A Grasshopper.

you notice that its body is put together in parts or sections. So are those of other insects—hence the name "in-sect." It has also two long curved feelers sticking out in front of its head (each is called an anténna and the two are called anténnæ). Then observe the two large eyes and the mouth fitted for biting or cutting through the leaf and the stalk of the grass. The outside of the body is hard and the inside soft—a dead, dried-up grasshopper has the form of a live one. A horse or a cow has its bones within and the soft flesh outside, but the insect has its bony part, so to speak, on the outside.

Next we must learn something of its mode of increasing—its life-history. Grasshoppers are male and female and the latter lays the eggs. Sometimes she does this in soft wood but generally in the ground, in the fall of the year, after the damage to crops has been done. The female makes a hole in the ground, in which she lays a number of tiny eggs. These are covered with a sticky substance which causes them to hang together like a pod. The nest or hole is then covered over and there they remain unseen through the winter. In the warm spring they hatch out and thousands and millions of young grasshoppers appear. Their appearance in large numbers is thus explained. They have no wings, but they can spring about, and they have vigorous appetites. Later on their wings appear, and now they are able to fly. They have done much damage where they were hatched and now they can fly away long distances, eating up and cutting down grass and hay and grain. Later on the females deposit their eggs, to be hatched out the next year. And so they continue year by year. Sometimes severe weather destroys their eggs or the young insects. Other insects may eat them up. Tiny forms of life (parasites) prey upon them. Diseases of various kinds destroy them. Knowing their mode of life, their life-history, the farmer can check them. For instance, when a field becomes infested with them, it can be ploughed up in the fall and their nests of eggs destroyed. A change or a rotation of crops is advisable.

Insects are arranged in orders. The principal basis of this classification is the form or structure of the wings. The grasshoppers are "straight-winged." Crickets and cockroaches belong to the same order. Entomology is the science of insects, as Botany is the science of plants. The Entomologist sometimes uses the word *orthoptera* when stating the order to which grasshoppers belong.

Moths and Cutworms.—In gardens and fields we often find the plants being cut off, but can see no insect or other

animal at work. If, however, we turn up the soil we find some dull-colored, greasy-looking caterpillars of almost the same color as the soil. On the top of the ring or section next to the head is a smooth shield; the head is smooth and shiny; there are some bristles along the side; and, when disturbed, the worm curls up. This is a cutworm; rather, this is one of the cutworms, for there are very many different kinds. They stay in the ground during the day and come out at night to eat off the leaves and stalks. These cutworms have been hatched from little eggs in the spring, summer, or fall. The cutworms, or caterpillars as they may be called, are quite small when first hatched, but they are heavy feeders and grow gradually to the size shown in figure 29, and by their feeding they do great damage in garden and field. When they have become full grown they burrow into the soil several inches and become a hard, deadlike mass similar to that shown in figure 29. This is what is known as the *pupa* of the insect. For several weeks, perhaps all through the winter, they remain asleep in this condition. Then another change takes place, the hard shell of the pupa cracks and there comes forth a moth with wings and legs and feelers, looking entirely different from the caterpillar or the pupa. These moths are the perfect insects; they are dull in color and are very active at night. They lay eggs which hatch into caterpillars, and the caterpillars go to sleep in the pupa form to again come forth as perfect moths. In most cases the eggs are laid in the fall, and the young caterpillars, less than half an inch long, lie in the ground quiet all winter. In the spring they attack the young crops and do most damage. About July they are full grown; then they go into the pupa state and come out moths in August. If the fields become weedy and there is much vegetation on the land in the fall the moths have a fine place for laying their eggs, and there is plenty of food for

the young caterpillars. Therefore the thorough cleaning of the land after harvest is one means of checking them.

The army worm also is the caterpillar of a moth, and is so called from its occasional appearance in immense numbers, when they devour nearly every particle of plant food in the

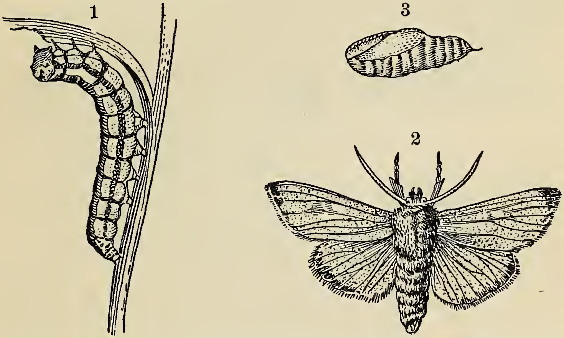


Fig. 29.—1. Army worm, pupa of same; 2. Moth into which it changes; 3. Chrysalis. This is a cutworm.

course of their march. Then we have other moths, the larvae of which live upon the fibre of clothing, clothes moths. All these are similar in form and in their changes, and all are very destructive.

Besides the egg we have, in most insects, the three forms or states, namely: the caterpillar, or *larva;* the *pupa*, or resting state; and the perfect insect, or *imago.* All moths, butterflies, bees, beetles, and flies pass through these same three states—thus we see that the insects differ from other animals both in their general form or appearance, and also in their method of growth or course of life. In the case of grasshoppers and some bugs there is no *pupa* or resting state.

BUTTERFLIES.—We frequently find mistakes made in the use of the words moths and butterflies. Both have scaly-wings as we see when we catch them and find the fine powder from the wings sticking to our fingers. This powder under a magnifying glass appears like scales of different shapes and colors. There may be several hundred thousand of these tiny scales on a single wing. However, there are differences in the two insects; the

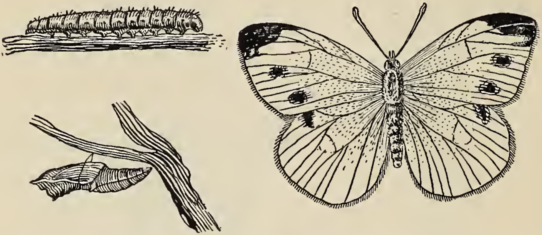


Fig. 30.—Cabbage butterfly. The caterpillar above on the left; the chrysalis below on the left.

moths usually fly about at night and the butterflies in daytime. Then if we examine the feelers or *antennæ* we see that those of the moths are usually feathered, while those of the butterflies are more or less thread-like and knobbed at the end. We can readily observe the changes in the common butterflies. The eggs are laid on the leaves of trees. Little, crawling, bristly caterpillars are hatched from these eggs. They grow in size, and it is only while in this larval state that that they are destructive. The caterpillars do injury principally to the plants of the garden, orchard, and forest. The *pupa* of a butterfly is called a *chrysalis*. It is usually rough and angular, whereas that of a moth is smooth and oval and often covered with a silky cocoon. From the *chrysalis* later on there comes forth a beautiful butterfly.

BEETLES are so common that nearly every person is familiar with their appearance. Some are very small; those found in this country are usually not larger than the figure shown here. In some foreign countries, however, they are found four to six inches long. Observe the three sections of the beetle. There are two pairs of wings, the upper pair quite hard or horny, covering the pair of filmy wings beneath. These sheath-wings are peculiar to the beetles. How many legs have they? Where are they attached to the insect? Find the eyes and observe the shape of the mouth and feelers or horns. The beetles go through much the same changes observed in moths. In the case of the beetles, however, the larval form is known as a grub. The white grubs found in the soil are the larvæ of large brown beetles.

Fig. 31.—A ground beetle, one of the "sheath winged" insects, very destructive to cutworms.

Fig. 32—Lady-bird beetles, or "lady-bugs." The straight lines represent the average natural length. These beetles are very destructive to plant lice.

Among the beetles we have a large number of very destructive insects. There is, for instance, the potato beetle which does so much damage to the potato plant by eating the leaves. See fig. 33. The hard-shelled beetle lays her orange-colored eggs on the under side of a leaf. These eggs hatch into the soft-skinned larvæ which eat the leaves. The larvæ change to pupæ and these to the full-grown winged insects. Since the larvæ feed on the leaves a simple remedy is to sprinkle some poison (Paris green) on the leaves just before they begin to feed, or to destroy the

eggs before these hatch. Why does the eating off of the leaves above ground injure the plant in producing tubers under ground?

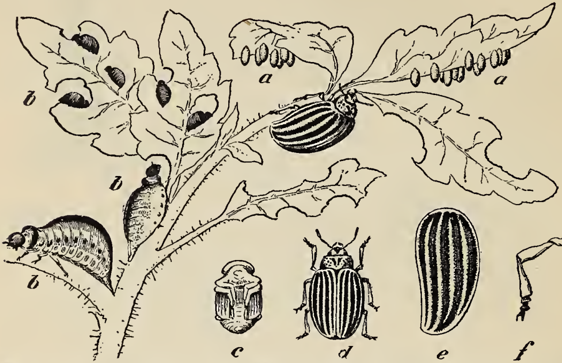


Fig. 33.—Colorado beetle or "potato bug." *a*, eggs on underside of leaf; *b*, larva that eats the leaves; *c*, pupa; *d*, imago or perfect insect; *e*, wing-cover; *f*, leg.

The turnip flea-beetle is sometimes wrongly called "the turnip fly." Our illustration shows the shape of the beetle and the larva much larger than life. The little black beetles pass the winter under any rubbish or clods of earth, and in the spring seek out some weeds near by that belong to the same family as the turnip, such as mustard and shepherd's purse.


Fig. 34.—The turnip flea-beetle.

As soon as the young turnips appear above ground they do great damage by eating holes in the leaves. One of the remedies appears to be the keeping of the ground clean of rubbish and the destruction of all weeds, especially wild mustard or charlock, false flax, shepherd's purse, pepper-grass, etc. The beetles lay their eggs on the roots of the turnip. In a few days the larvæ or grubs hatch out and feed upon the roots.

When full-grown they enter the pupa state in the ground and emerge full-grown beetles. There may be several broods in a season. By having the ground in good condition before the seed is sown the young plants grow rapidly and soon get the start of the beetles.

The weevils also belong to the same order as the beetles, and are most injurious to grain crops. The pea-weevil may be taken. Its eggs are laid on the outside of the young pod. The larva hatches and eats its way through the pod and into one of the peas, where it lives upon the substance of the pea. The change to the pupa takes place in the pea. Sometimes these beetles come out in the fall, but in most cases they stay inside the peas until spring. They do great damage to the peas by destroying the germ. All grain weevils may be killed by placing in the bins some poisonous substance that will readily evaporate, such as carbon bisulphide. The bins are shut tight and the beetles are killed by the fumes. If the peas are kept over until two years old the beetles will mature and die in the bins the first year, and the seed then sown the second year will be entirely free from the pest. These beetles do not lay their eggs, or oviposit, on dry peas. Any seeds of which the germs have been eaten by the grubs will, of course, not sprout.

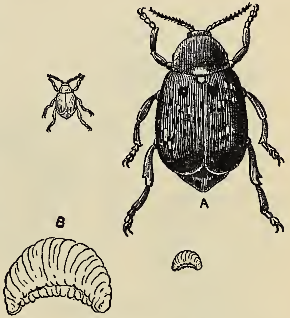


Fig. 35.—Pea-weevil or "pea bug," life size. A, the mature beetle, enlarged; B, the larva or grub, enlarged; larva life size.

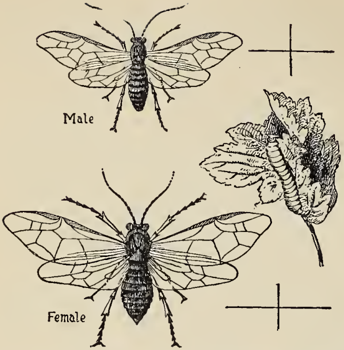


Fig. 36.—Currant sawflies; grub or larva on the right. The perfect insects have yellow bodies. The eggs are laid along the ribs on the backs of the leaves.

Fig. 37.—Larvæ of currant-worm, green, dotted with black spots.

Transparent-Winged Insects.—This order includes ants, bees, wasps, hornets, and sawflies. The scientific name for this order is *hymenoptera*. The study of an ant hill will be found very interesting. We need not look for any in a well-cultivated field. No warning need be given that in the study of bees, wasps, and hornets great care must be used. As for sawflies, illustrations given in figs. 36 and 37 will serve to make their acquaintance—to "identify" them. They are called sawflies because they are able to cut or saw into leaves with their abdomen in order to make nests for their eggs. The stems of wheat are sometimes cut off by sawflies, and the galls in oaks are produced by gall-flies which also belong to the order of transparent-winged insects.

BUGS—All bugs are insects but all insects are not bugs. When we speak of bugs we mean such insects as the many kinds of plant lice. *Aphis* (plural, *aphides*) is another name for a plant-louse. This order of insects is known as the half-winged (*hemiptera*). Some have only two wings and some have four. We find plant lice quite common on many house plants and garden plants. Orchard trees, cabbages, hops and many other plants are much infested by lice, some very small, some large enough to be easily studied. There are some also

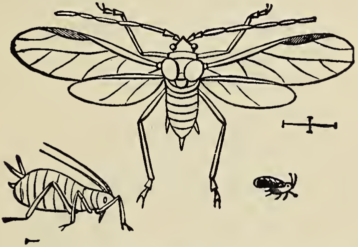


Fig. 38.—Plant lice, half-winged insects. Cross lines and small figure show natural size.

that do much damage to grain, especially wheat, barley, oats, and rye. The plant louse or aphis is generally green or black, sometimes yellow; in fact if we observe closely and frequently we shall come to the conclusion that the color of the aphis is not unlike the color of the leaf, stalk or head that it feeds upon. We notice also that the leaves of plants upon which the aphides are found in large numbers soon curl over and become sickly. If we examine a large plant louse we find that it has a strong beak about one-third the length of its body, so that it is well fitted to pierce through the skin of plants and to suck the sap. They live on liquid food. Another thing we observe in regard to them is that the lice are found in large numbers, and they multiply very rapidly. Some lice feed largely upon other insects, and are therefore beneficial.

In the case of house plants, garden plants and orchard trees we can wash and spray with solutions that destroy the lice, but with lice that injure the grain such means are not yet practicable. Why then do not the lice multiply so as to eat up everything in the fields? Simply because there are other insects that keep them in check. There are some tiny flies that attack the lice and lay their eggs right in the bodies of the lice. These parasites soon kill the lice. Other insects are destroyed in the same way, such as caterpillars and grasshoppers. If we carefully examine the leaves of trees or other plants infested with lice we may find some of the beautiful little lady-beetles and their larvæ feeding upon the lice. Another enemy of lice is the aphis-lion, the larva of a lace-wing fly.

Fig. 39.—Caterpillar covered with parasites.

Flies—If you examine a common house-fly or a mosquito, you observe that it has only two wings. Here then we have another order, that of the "two-winged" flies, known as *diptera*. The Hessian fly, the wheat midge, the many flies of root plants, mosquitoes, fleas, and many of the flies that annoy stock—all have two wings only and belong to this order.

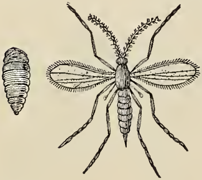


Fig. 40.—The Hessian fly, a two-winged insect.

The Hessian fly appears in spring as a small winged insect with long legs. The female lays about twenty eggs in the fold or crease of the leaf of the young wheat plant. After a few days the larvæ hatch and get down between the stem and leaf-sheath. Here they feed on the plant and weaken it so that the heavy head soon after topples over and the grain is destroyed. The eggs may be laid either in the spring or in the early fall. When the latter is the

case the young insects generally pass through the winter in the pupa state, known as the "the flax-seed" condition, because the pupa case is like a flax-seed. Any such found in wheat screenings should of course be burned, and where found in the field the stubble should be cut and burned. The principal remedy for the Hessian fly then is to completely burn all material containing the young insects and to change from wheat to a cultivated crop, as roots or corn. The Hessian fly attacks wheat, barley, and rye.

The Clover-Seed Midge lays its eggs in the young clover-heads where the larvæ or orange-colored maggots hatch out and do much damage. Then they fall to the ground and complete their changes, appearing as full-grown insects towards the latter part of summer, ready to do damage again to the second crop of clover. Where the midge is doing much damage it is evident that the pasturing off of the first crop of clover will tend to destroy the larvæ. The first crop also may be cut early, when in full bloom, before the first brood of maggots develop. A regular rotation of crops tends to keep in check these and many other injurious insects.

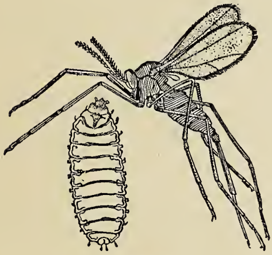


Fig. 41.—Midge and larva.

CONCLUSIONS:

1. Insects are so-called because they are made up of sections. There are three main parts, the head, the thorax or trunk, and the abdomen. The thorax and abdomen are also made up of sections (see illustrations).

2. The legs and wings of the adult or perfect insect are all attached to the thorax.

3. The adult insect usually has two large, compound eyes, that is, eyes made up of many parts. The antennæ, or "feelers," are attached to the head. Some persons think that insects hear by means of their antennæ.

4. Insects breathe, not through the mouth, but through small holes or openings along their sides. These are called "spiracles" and are connected with air tubes passing through the body.

5. As a rule insects pass through three forms after coming from the eggs, known as: first, the *larva* (caterpillars, grubs, slugs, maggots, etc.); second, the *pupa* (called chrysalis and nymph in certain forms); and third, the *imago* or perfect or adult insect (butterflies, moths, beetles, flies, etc.).

6. Insects are kept in check by nature in various ways. They destroy one another; for instance, the lady-bird beetle, the ground-beetle, the tiger-beetle, the aphis-lion prey upon other insects. Toads and lizards devour large quantities of insects. Many birds feed upon insects almost entirely, and are hence called "insectivorous birds."

7. Insects lay eggs when in the imago or perfect form, but the damage to plants is done principally when in the larval form. The imago or adult insect is full grown when it comes from the pupa.

8. Insects injure plants either by biting and eating the foliage and other living parts, or by sucking their sap. Biting insects, such as cutworms and grubs, may be destroyed by placing poison (Paris green, etc.) on the plants. Sucking insects, such as plant-lice, are destroyed by dusting the plants with insect powder or by spraying them with an emulsion of kerosene and soap—thereby closing up the breathing holes of the insects.

9. Where the insects of field crops cannot be destroyed by spraying, the best practice is to keep the fields and fence corners clean and free from weeds and rubbish, to thoroughly till

the ground, to adopt a good system of rotation of crops, and to keep the seed grain clean.

10. Insects are arranged according to their wings. The following are some of the orders:

1. Nerve-winged or *neuroptera* ....dragon-flies and may-flies.
2. Straight-winged or *orthoptera*.........grasshoppers and crickets.
3. Half-winged or *hemiptera*.............bugs and plant-lice.
4. Sheath winged or *coleoptera* ....beetles.
5. Scaly-winged or *lepidoptera*...........butterflies and moths.
6. Two-winged or *Diptera* ....house-flies and mosquitoes.
7. Transparent winged or *hymenoptera* ...bees, wasps, sawflies and ants.

NOTE.—The scientific names for the above orders of insects are accented on the second syllable before the last, thus: neu-róp-tera, or-thóp-tera, etc. These words are derived from the Greek word *pteron*, which means a wing.

CHAPTER XVIII.

THE DISEASES OF PLANTS.

Effects of Disease.—House plants, especially those with large leaves, often become covered with small dark spots which gradually become larger and make holes in the leaves, which soon die. We can see the same on the leaves of the apple tree, the pear tree, and can also find them on the leaves of the shade trees. This spotting of the leaves is a disease. We can find similar diseases on the leaves and stalks of grain.

When plants become diseased, they lose some of their vitality, as we say, and we need not look for much fruit or grain. It is therefore of importance that disease among plants be prevented, just as we try to prevent sickness of animals, or of ourselves.

Again, in addition to the disease attacking the leaf, the branch, the stalk, or the root, it may attack the fruit. You have seen the brown and black spots or scabs on the apple and the pear; you have seen the ear of corn all overgrown with smut, and the heads of wheat and other grains covered with a dirty growth; you have seen the potatoes affected by the "scab" and the "rot." All of these are cases of disease. Whenever the plant is diseased in any part the fruit or the seed will be found to be either small and of a poor shape or else entirely useless. Scabby apples, smutty corn, and potatoes affected with the "rot" are not salable, they are of no use, in fact they are harmful. Why are they harmful? In the first place, such food is not wholesome. Further, we know that very often one animal will take disease from another—scarlet fever, diphtheria, small-pox, and even influenza, or a "cold"

will pass from one person to another. It is so with the diseases of plants. If potato "rot" gets a start it will go from potato to potato until all are affected.

If we allow smut to stay in the corn field it will spread. If a cherry or plum tree has black-knot the disease will soon attack the other trees until all are killed or nearly killed, and no good fruit results. This point, therefore, we should firmly fix in our minds, that whenever disease appears upon a plant we should first of all try to prevent it from spreading by destroying the diseased part, or, if necessary, the whole plant. And there is only one effective way of destroying disease in plants, and that is by *burning*. It will not do to cut off a black-knot limb from a cherry tree and throw it in the fence corner or on the brush heap. The disease will spread from the cut off branch. It should be burned up. So with the peach tree affected by "the yellows." Once the disease has started it is useless to try to *cure* it or to remedy it. The diseased tree or plant or the diseased part should be destroyed. But we can prevent it from spreading, if we take action in time. Substances and methods used for preventing the spread of the disease are called "preventives."

Nature of Disease.—If we begin with a giant oak or white pine and arrange the plants known to us in order of size down to the smallest grass plant, only a couple of inches high, or the still smaller moss, we shall take in a great many plants, but not all. There are very many others still smaller and much simpler in their form and mode of growth. Perhaps you have observed the greyish lichen growing on the old fence rails or on the side of a boulder. It is not much thicker perhaps than this paper and yet it is a kind of plant—it is one of the lower orders of plants. Then you have seen the blue mold or *fungus* on the side of a cheese, it also is a low form of plant life. The smut growing in the ear of corn, the rot of the potato, the rust of wheat, and the other forms of

disease in vegetation are all minute plants. These lower forms of plants live in and upon the higher plants, taking the food out of the plants and thereby checking their growth and even killing them. Where did they come from? The field crops grow from seeds, and when they are ripe, they produce other seeds that will again grow. Now these small plants, these disease plants, grow from tiny seeds generally called "spores," and when they mature they form other spores which will be carried about by the wind, settle on other plants, start growing there, and thus spread themselves. A small dark speck appears on the leaf of a house plant—the spore has started to grow. The speck grows to a large spot, it soon becomes darker, then the whole spot or scab breaks open—the spores are ripe and fall off or are blown away, and the life of this disease plant begins again on another leaf or on another plant. Why did we not see the spores at first? Simply because they were too small, they can be seen only by a magnifying glass or a microscope—hence these plants are sometimes called microscopic plants.

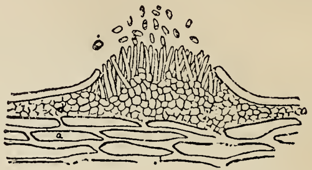


Fig. 42.—A diseased leaf. The minute plant causing disease is growing in a leaf and is throwing off ripe spores (seeds), which will settle on other leaves, and thus cause the spread of the disease. A ragged hole will remain in the leaf, usually brown in color on the margin

Prevention of Disease.—If we could destroy these spores we would, of course, prevent the growth of the disease plants. In addition, therefore, to destroying all plants and parts of plants known to be diseased, we should use preventives whenever we think the disease is likely to be started. The leaves and stalks of house plants are washed from time to time in order to clean them from dust and also to wipe off disease spores. One of the principal substances used for killing these

How orchards are sprayed. The cart contains a barrel holding the spraying mixture. A force pump is attached to the barrel; with this the *fungicide* or *insecticide* is sprinkled over the trees.

spores in the case of trees and shrubs is bluestone (also known as sulphate of copper). When the fruit grower sprays his trees to check disease on the branches or leaves or fruit he uses a solution of bluestone. Sometimes he makes a mixture of Paris green and bluestone, the Paris green being to kill all insects that eat the leaves, and the bluestone to destroy the spores or

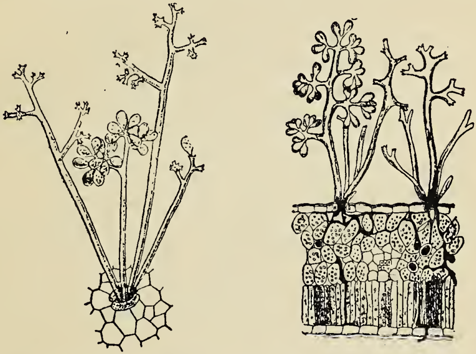


Fig. 43.—Two forms of minute plants growing in leaves and in fruit of plants, causing disease of plants. Very much enlarged.

seeds of disease. There are so many different forms of disease (rusts, smuts, mildews, blights, etc.) that we have not space to mention them. But we shall here give only the simplest modes of preventing disease. Smut, in growing wheat, generally comes from wheat that has grown in fields where smut existed the year before, that is, the wheat when sown had the spores of smut already in the grain. The disease then can be prevented by destroying the spores in the seed that is sown. Make a solution of one pound of bluestone or copper sulphate in twenty-four gallons of water. Soak the grain to be sown in this solution for from twelve to sixteen hours. Then the seed may be dipped in lime water for five minutes. After being thus treated it may be sown and no smut will appear. Sometimes the spores of smut

on the seed wheat are killed by dipping it into hot water shortly before sowing, but the bluestone treatment is preferred.

The potato tubers are sometimes found to be covered with a rough scurf. On cutting the potato it will be found to be affected also under the skin. This roughness is the result of a disease called the potato scab. If scabby potatoes are planted the tubers produced from them will be scabby, and if clean potatoes are planted in the ground where scabby potatoes were lately grown, the new crop will likely be scabby. The best rule to follow, then, is to plant only perfectly clean potatoes in ground where no scabby potatoes were previously grown. Some success has been had from rolling scabby potatoes in sulphur before planting, but it is much more satisfactory to destroy the scabby potatoes and plant only clean tubers in clean ground.

The rot or blight of potatoes is quite a different disease, produced by a different fungus. Different names for this disease are rot, blight, and downy mildew. It is also called "late blight," because there is a somewhat similar disease that attacks the plants earlier in the season called "early blight." The potato leaves show brown spots. These spread rapidly, especially if the weather is warm and moist. The under sides of the leaves soon become covered with a light colored growth; these are the spores or seeds growing on tiny threads. The spores appear to fall to the ground and by rains are washed through until they reach the tubers, to which they at once attach themselves and then begin their growth. Then the roting of the potato begins.

It is thought by some that the disease in some way reaches the tubers by way of the stem. It may be that the disease is transmitted from the leaves to the tubers in both ways. To prevent the spread of this disease the growing plants are sprayed or sprinkled with a solution of bluestone (sulphate of copper). The disease is sometimes called a *fungus* (plural, *fungi*), hence the preventive is called a *fungicide.*

CHAPTER XIX.

ROTATION OF CROPS.

Importance of Rotation.—If we get a large yield of any crop from a certain field, should we not grow the same crop year after year? This is done, for instance, on the rich prairie soils, where wheat has been grown year after year upon the same soil. In former times this was done also on our soils when they were new and rich. But what has been the result? The soils of many farms have run down and good crops are got only by heavy manuring. In the best farmed countries of Europe, where, after the experience of hundreds of years, larger yields of wheat and other crops are obtained than we get in Canada, it has been found advisable to change the crops grown from year to year. The experience of Europe and of Canada both prove that the best farmers succeed in crop growing only by rotating or changing their crops.

Reasons for Rotation.—1. The different crops, as we have seen, are all made up of the same elements, and take up food from the soil; but they do not all take up soil food of the same amount or in the same form. Thus the potato, tobacco, and fruit trees require a great deal of potash; the grain crops take up more phosphates. The crops differ in their feeding just as animals differ. The dog does not eat just what the cat does, nor the horse just what the pig does. If cattle and sheep are pastured together, the sheep will pick out certain weeds and grasses, and the cattle may prefer others. Wheat, for instance, requires nitrates as one

of its most important foods, and if we grow wheat year after year we may soon exhaust the nitrates available; but if we grow wheat one year and some other crop the next, the second crop may be able to feed well and flourish upon food left by the wheat.

2. The plants have different methods or powers of getting the same kind of food. Thus clover or peas will get nitrogen by means of the little knots or tubercles (page 57) upon their roots, whereas wheat has not this power to take up free nitrogen. A clover crop will need more nitrogen than a crop of wheat, and yet, because of the root tubercles, we do not apply nitrates to a clover crop, but nitrates may be applied to wheat with good results.

3. The plants have different kinds of roots. Those of barley are very short, those of wheat longer, those of red clover and lucerne still longer. A deep-rooted crop feeds lower down than a shallow-rooted crop. If, then, we grow clover this year and wheat the next, we grow these crops, to a great extent, in two different soils. We use surface soil for one and under-soil or sub-soil for the other. By changing from a shallow-rooting crop to a deep-rooting, or from a deep-rooting to a shallow-rooting, we, as it were, change the soil from year to year. This is one of the most important points to observe in rotating crops.

4. By rotating crops we change the treatment of the same soil, since we do not treat the soil exactly alike in preparing it for different crops. Some crops, also, are cultivated and others are not. We thus give the weeds different treatment. The weeds differ as do the crops—there are annuals, biennials and perennials; there are long-rooted and shallow-rooted; there are early seeding and late seeding weeds. The same treatment year after year may be just the right treatment to encourage certain weeds to grow and spread. The growing of wheat year after year in the west is causing the spread of some very noxious weeds. By changing the crops, and therefore the treat-

ment of the soil, we do not give the weeds so good a chance to rob the crops and infest the fields.

5. The insects also make their homes on certain crops and in the ground. By rotating the crops we disturb the insects and help to keep them in check. If we remove the food of the insects, bury them or their eggs deep in the soil, or turn them up to the frost we are helping to destroy them.

6. Some crops mature early in the year, as fall wheat and barley; others late in the fall, as corn and roots. Some are in the ground but a short time, others for a long time, and so they have different lengths of time for feeding. It is often helpful to have a long-feeding crop followed by a short-feeding crop, as in the case of roots followed by barley.

We may then sum up by saying that crops differ:

As to the kind of food which they take up;
As to the amount of different foods which they take up;
As to the length of their feeding roots;
As to the length of time that they are feeding;
As to the treatment we give them (cultivated or not);
As to the weeds that associate with them;
As to the insects that infest them;

For these and other reasons the best farmers always pay careful attention to the proper rotation of their crops.

Samples of Rotation.—Let us take what is called a four-year or four-course rotation—turnips, barley, clover, wheat. The first crop requires thorough cultivation and gives a chance to manure heavily for the entire course. Turnips are biennials, and therefore long-growing, feeding until late in the year. Then comes a shallow-rooted, quick-growing crop of an entirely different nature. The clover at once follows barley and sends its roots deep. It feeds upon the free nitrogen of the air in the soil through its root tubercles, and when plowed in leaves a large quantity of material in the roots and stubble to make food for the wheat. The manure applied with

the roots has by this time been well worked over. Last comes the wheat with roots of medium length, feeding in the fall and spring and coming to maturity in the summer of the fourth year. A variety of crops for the farmer's use is at the same time obtained.

Here are some other rotations that may be examined :

1. Wheat	1. Barley	1. Wheat	1. Barley
2. Hay	2. Hay	2. Hay	2. Hay
3. Hay	3. Pasture	3. Pasture	3. Oats
4. Pasture	4. Corn	4. Pasture	4. Peas
5. Oats	5. Oats	5. Oats	5. Corn
6. Peas	6. Peas	6. Peas	
	7. Roots	7. Corn	

The system, of course, must be suited to the soil, the kind of farming adopted, and the circumstances of the farmer. Rotations may have to be changed from time to time, but, if the principles upon which rotations are based are well understood, there will be no difficulty in making changes, and in forming rotations suitable to the needs and conditions of the farm. The four-course rotation may be taken as a basis, and changes made to lengthen it; thus corn may be put in place of roots, and barley may be seeded to clover and timothy, and a year or two of hay and pasture, or both, may be had before returning to a cereal crop. If the soil is the farmer's capital, then growing the same crop year after year leaves part of the capital idle. Rotating the crops causes all of the capital to do its share in turn in producing income, and, it may be, in increasing the amount of capital.

A "reaper" cutting and binding the wheat into sheaves.

PART IV.

CHAPTER XX.

THE GARDEN.

"A small garden well kept will produce more than a large garden neglected."

Selection of Garden Plot.—The garden plot should be near the house, and at one side rather than in front of the house. A neat, dry walk should lead to it. A loamy soil, well drained, and well manured will be suited to the crops required. If it is long and narrow in shape rather than square, much of the cultivation may be done by horse help. A wind-break or shelter-belt of spruce or other trees will add to the appearance as well as to the value of the garden.

Garden Crops.—In every farmer's garden there may be grown the following crops:

Beets,	Rhubarb,	Strawberries,
Carrots,	Tomatoes,	Raspberries,
Potatoes,	Celery,	Currants,
Parsnips,	Egg-plant,	Gooseberries,
Radishes,	Lettuce,	Spinach,
Cabbages,	Peas,	Sweet Marjoram,
Cauliflowers,	Beans,	Thyme,
Sweet Corn,	Horse-radish,	Sage,
Onions,	Cucumbers,	Summer Savory,
Asparagus,	Pumpkins,	Parsley,
Salsify,	Melons,	Garden Mint.

Much that has been said about field crops, their mode of growth, and their enemies, both insects and diseases, will ap-

ply to the crops of the garden. More may be learned by working among the plants growing in the garden, and at the same time *using your eyes.*

What parts of the following plants do we use as food? Common radishes, horse-radish, cabbage, cauliflower, lettuce, celery, artichokes, onions, asparagus, potatoes, rhubarb, and spinach.

Explain the bleaching out of celery by banking up. Will the stalks bleach out if grown on the level close together?

What is the difference between top onions, potato onions and onion sets?

Is lettuce an annual or a biennial?

Classify the crops given above as annuals, biennials and perennials.

Are all the blossoms on a cucumber vine alike? Which produce fruit? Is the cucumber plant monœcious or diœcious? See page 70.

The Strawberry.—If you pull off the petals of a rose blossom you find the stalk on which it grew is somewhat enlarged at the end. This little swollen end is called the "receptacle." In the case of the strawberry which we eat, we see a large number of small hard grains in little pits on the surface of the soft, fleshy fruit. If the hard grains were large enough we could open them, and see that each one is a little seed. The part we find so pleasant to eat, then, is not the seed. What is it? By examining the stalks bearing green berries as well as those bearing ripe berries, we observe that it is the swollen end of the stem, that is the receptacle. If a ripe berry is cut in two, the seeds will be found to be connected with the stalk. The strawberry plant is a member of the rose family (*rosaceæ*) to which belong a large number of our common fruit-bearing plants, as well as some other common plants, such as the plum, the cherry, the strawberry, the raspberry, the blackberry, the wild rose, the hawthorn, the pear, the apple, the quince.

Fig. 44—A strawberry plant properly set out.

Compare the leaves and blossoms of the strawberry, the apple, and the wild rose ; also the fruit of the hawthorn, the wild rose, and the mountain ash. Observe how the leaves are arranged on the branches. At what place do the blossoms appear ? How many petals in every blossom ?

In a patch of wild strawberries you find that the plants spread in all directions, that the fruit is small in size and small in quantity in comparison with the large amount of leaves and runners. Most of the plant food is being used up in forming runners and leaves. If we wish fruit large in size and large in quantity we must plant improved varieties in rows at least three feet apart, and we must keep the space between the rows clean of weeds and runners.

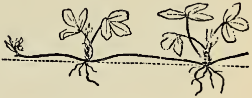


Fig. 45.—A strawberry plant reproducing by a "runner."

The strawberry is a perennial, but as the plants have been developed by cultivation and selection they tend to go back to their original habit of producing small berries. Therefore it is best to grow fruit only on young plants. The plants send out runners which take root and form new plants, and the best berries are on these new plants. The old plants soon become of little value. Therefore the beds must be renewed.

If you examine the blossoms of many kinds or varieties of strawberries you will find that those of some are perfect, that

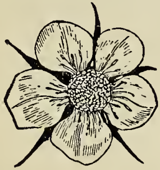


Fig. 46.—A perfect strawberry blossom having both pistils and stamens.

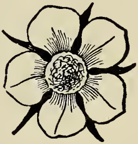


Fig. 47.—An imperfect strawberry blossom having pistils, but not stamens.

is, they have both pistils and stamens (fig. 46) ; these will of themselves produce fruit. The blossoms of others, however,

are imperfect, they have pistils but no stamens (fig. 47); these will not form fruit, unless pollen from perfect blossoms is brought to them by the wind or by insects. Some of the best producing varieties of strawberries have imperfect blossoms; they are pistillate varieties and if we wish them to produce good crops we must plant alongside of them some plants of varieties bearing perfect blossoms. This is very important and should be well understood. In some of the varieties of fruit trees also, the blossoms are either imperfect or else able to fertilize themselves only with difficulty, and the planting of varieties whose blossoms produce an abundance of pollen is of great help.

RASPBERRIES.—When you pull off a strawberry, part of the stem comes with it; but when you pull off a raspberry, it comes away freely from the stem, leaving a pointed end. This is because the receptacle or end of the stem is the fleshy part of the strawberry, whereas the raspberry is a collection of soft fruits distinct from the receptacle. In the case of the strawberry, we eat the end of the swollen stalk; in the case of the raspberry, we eat a cluster of fruits like small cherries.

The roots of raspberries are perennial and the canes are biennial. Thus, canes grow up one year, bear fruit the second year, and then die. Therefore, in pruning the bushes we cut away all the canes as soon as they are done fruiting, and save the new canes for next year's fruiting.

The bushes are increased or propagated by suckers or by the tips. The suckers, which grow up from the roots, are removed by cutting away below the soil and then set out as new plants. The tips of the canes are bent over and buried in earth, when they take root. The red varieties are propagated by means of suckers or root cuttings; the black-cap and purple cane varieties by the tips.

A commercial strawberry field at picking time. Strawberries may be grown in "hills" or in "matted rows." When in "hills" the "runners" (see Fig. 45) are cut off. When in "matted rows" they present the appearance shown in the illustration.

GOOSEBERRIES.—Our garden varieties have been developed from natives of Europe and of America. Fig. 48 shows a fruit cut across containing the seeds, which are fastened to the skin by little threads. The form is similar to that of a grape. New bushes or plants are produced by layers and cuttings. In layering, a branch is bent over, a little notch cut in the under side where it will be under ground, then bent down and covered with soil, leaving the tip above ground. After a little, roots will appear near the notch, and later on the branch may be cut from the bush and a new plant will thus be started. In using cuttings, good thrifty stems or branches about six inches long are cut in the fall or early in spring and set out with the top bud just above ground. These are covered for the winter. The next year they form good roots, and the following year may be set out in rows. To prevent suckers, the buds below ground are rubbed off.

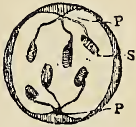


Fig. 48.—A gooseberry, showing seeds, *S*, attached to skin at *P*.

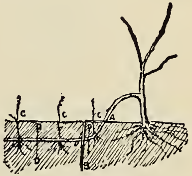


Fig. 49.—Reproducing plants by layering. *A* is branch bent over and buried, held down by stake *B*. New shoots *C* start up, which are then cut off from parent plant at *D*.

Seedlings of all the berries may be obtained by rubbing up the ripe fruits with sand to separate the seeds and pulp. The sandy seed is sown on the surface of a finely worked bed, well enriched with decayed manure. The soil is kept shaded and wet with a fine spray. The plants are afterwards pricked out in another bed with more room and allowed to fruit to test.

CURRANTS.—These are grown very much as we grow gooseberries. Most of our varieties belong to three classes:

1. The Flowering Currant, which is grown as an ornamental shrub. Its sweet-scented yellow flowers appear early in the spring. The fruit is black and of decided flavor or taste. By

cultivation, it may be used in the future as a fruit producer.

2. The Black Currant, which came from Europe. The fruit is black, and has a peculiar odor.

3. The Red Currant, with berries red and white.

Enemies of Garden Crops.—In connection with field crops we referred to the enemies under two heads—insects and diseases. These enemies are also to be found in the garden, and, as garden crops are relatively more valuable than field crops, they should be watched very closely. Many of the field insects will be found in the garden, especially the many small insects called by the general name "flies," which, of course, are quite different from our house flies. Then there are caterpillars of many sizes and colors, some of which closely resemble or "imitate" in color the plants on which they feed. A very common enemy is the cutworm. Frequent cultivation and the turning up of the soil will bring them to light. The birds will pick them up. Diseases are the second-class of enemies, which appear in so many forms, variously named rust, leaf blight, anthracnose, mildew. Strawberries, for example, are greatly injured in producing fruit because of leaf-blight. Spraying with sulphate of copper *(Bordeaux mixture)* before the fruit begins to enlarge will check it. In the diseases of currants, gooseberries, etc., the same may be used. Full instructions as to what to use and how to apply the various preventives may be got in the bulletins of the various Departments of Agriculture. All that need be said here is that thrifty plants grown in well-tilled soil, kept clean from weeds and rubbish, and properly fertilized, are least likely to be attacked by disease.

Earthworms.—These must not be confused with cutworms, wireworms, and other insects that destroy crops. Earthworms play a very important part in working over soil and in producing fine mold. Their effect may be noticed especially in lawns. They come to the surface at night and after rains, bringing up soil from beneath.

CHAPTER XXI.

THE APPLE ORCHARD.

THE APPLE.—Let us take a fair-sized apple of good shape, cut it through as shown in fig. 50. We see that the stem is connected with the core, and beyond it at *C* are the small ends of what appear to be leaves. These are the ends of the calyx leaves. The core is the seed box; it is made up of hard, tough, fibrous material, *E*, in which are the seeds, *A*. If you cut another apple across the core you see the five seed boxes. The apple, then, is firmly attached to the branches by the stem which is closely connected with the core. The part *T*, outside of the core, is made up of the enlarged stem and the lower and thicker portion of the calyx leaves which have closed over the seed forming portion of the blossom (the ovary), and have become thick and juicy. What we eat, then, is really the leaf portion of the blossom, united with the swollen stem. Cut a thin slice across the apple and hold it up to the light—you will observe five parts somewhat resembling the blossom of the apple. Frequently the five tips of the leaves at *C* are easily observed. The relation of the apple to the blossom is now known.

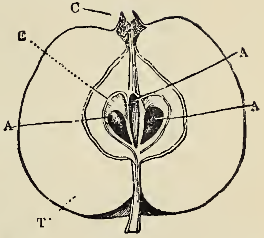


Fig. 50. Section of a fully formed apple. *A*, seeds in seed-box or core, *E*; *C*, the calyx end; *T*, the pulp.

Fig. 51. Section of an apple blossom, showing how the apple begins to form.

SEEDLINGS.—If we plant some apple seeds, plants will spring up that, after a few years, will become trees and bear fruit. These trees are known as "seedlings." But, what at first appears strange, they are not likely to bear apples similar to the apple from which we took the seeds; in fact, the apples may be of little use. And why so? Because the apple, in its wild or native form, has a small, rather poor fruit, and the many varieties have been produced by careful cultivation and selection. In this way varieties are obtained that are different in their hardiness and different in shape, size, color, and flavor. As is the case with other plants, while we develop them for producing fine fruit they frequently become more tender in stem and roots, and, therefore, the nurseryman has to use great skill in producing plants that are both hardy and productive of good fruit. If we grow apples from seeds only, the hardy seedlings will grow to a producing age. In this way we can obtain trees with hardy roots, stems, and buds. If, now, we can use these roots and stems for our trees, and at the same time cause them to produce highly-flavored fruit, we shall get trees such as we desire. This may be done by grafting.

GRAFTING.—The hardy stem and root is called the *stock.* The part to be grafted on to the stock is called a *scion.* The nurseryman selects the young seedlings and cuts small branches as scions from the trees of improved varieties such as he wishes to produce. The scions are cut in the late fall after the leaves have fallen, or in early spring before the buds start to open. At that time the branch is dormant or asleep. The grafting is done, as root-grafting or as top-grafting, before the growth starts in the spring. In root-grafting, the stock and scion may be cut across as shown in Fig. 52. This is called whip or tongue-grafting, and is the method of cutting when both are of same size. When the stock is large and the scion small, the latter is cut wedge-shaped, and the former is split so as to take in the little wedge end, as in Fig. 53. The scion is

placed in the stock and the cuts are all covered with grafting wax, which is composed of a mixture of tallow or linseed oil,

Fig. 52.—Whip or tongue-grafting on root. Used also in the case of small stocks.

Fig. 53.—Grafting in cleft or split limb. Used in the case of large limbs. In very large limbs two scions are inserted on opposite sides of the cleft.

beeswax, and resin (about 1, 2, 4 parts by weight of each). A very important point is to have the layer just underneath the bark (the cambium layer) of both stock and scion exactly opposite or against each other. Why is this important? The living part of a trunk or branch lies between the sapwood and the bark; it is the thin layer of moist woody fibre just underneath the bark. If we bring the living layer of the stock and the living layer of the scion together, the sap from the one will flow into the other, and the root and stem will continue to nourish the new branch. The nature of the fruit depends upon the kind of branch.

Pruning.—The leaves and new branches are formed before the fruit, so that, if the tree is inclined to become very branchy, most of the food may be used up in producing new wood, and very little will be left for fruit. Therefore, in many varieties, pruning is very important. The proper time is to begin with

the tree as soon as set out, and to prevent the growth of too many limbs by cutting off limbs when small shoots and by rubbing off buds that are not required. Limbs growing too long may be "stopped"; that is, pinched off at the end. The thinning out of fruit will, for the same reason, have the effect of producing larger fruit.

Feeding the Trees.—Three crops are produced yearly in the orchard—new leaves, new branches, new fruit. The tree needs food for all three. It is necessary to have the land drained so that the roots can go deep into the soil. Then the surface soil must be kept well cultivated about the young trees, that the moisture may be saved and the air get into the soil. But, in addition, food must be supplied, not merely to the young tree, but also to the old tree as long as it is expected to bear a crop. Wood ashes are the mineral or soil matter of the trunks and branches of trees, therefore we may conclude that wood ashes are an excellent food for fruit trees of all kinds. Wood ashes contain lime, potash and some phosphates. If any other manures are applied they should be such as fine bones, which contain phosphates and lime. Potash and phosphate manures are the proper food for vines and trees producing fruit. The proper place to apply such is, not close around the trunk, but beneath the ends of the branches. Why?

Suggestive :—

If we plant the seed of a northern spy apple, may we expect that the tree thus produced will also bear northern spy? How are new varieties produced? What might be done with a seedling apple tree that bears poor fruit in order to make it a useful tree? In peach-growing, is it best to have a large number of small peaches or a smaller number of large peaches? Good orchardists now thin their peaches and plums. Why?

Did you ever notice how a wound made by cutting off a branch of a tree heals? If a stub six inches long is left it dies back, rots, and finally falls away, leaving a hole in the tree trunk. If cut close new wood grows over the wound until, in time, it is entirely covered. In pruning, then, cut close to the main branch or tree trunk.

Remember that the tree itself is a crop, taking its food from the orchard soil. It is bad practice, therefore, to raise other crops such as grain or roots between the trees. This may occasionally be done with good tillage and good manuring, but more often the trees are starved as a result.

PART V.

CHAPTER XXII.

HORSES.

Origin of Horses.—These animals are not natives of America. The Indians had no horses before the white-man came—they went afoot or by canoe. The wild horses of America are the offspring of escaped animals. Geologists have found traces of small animals, supposed to be the ancestors of the horse, in some parts of America, but these had all disappeared long before Europeans arrived four centuries ago. Horses, as we know them, were originally used in warfare. At present we have many kinds of horses, but all have doubtless come from the same stock or kind. When the wild animal was first tamed or domesticated, we do not know. Climate and food, which varied in different countries, and the uses to which horses were put, gradually produced some changes in form and appearance. Animals that showed the qualities desired—such as size, color, form, strength, and fleetness—were carefully treated, and thus there were developed in different countries horses of different breeds. Some desired horses for heavy work, animals of heavy body, stout limbs, and strong muscles. Others desired horses for speed, animals of lighter frame, smaller bone, and sound lungs.

Kinds of Horses.—Two classes of horses have resulted. We shall mention here only four breeds of each class. These have become fixed or definite in their characteristics. The

only way in which to become familiar with these different breeds is by observing the living animals.

Heavy horses:

1. The Clydesdale, from the valley of the Clyde in Scotland.
2. The Shire, of the East-central shires of England.
3. The Suffolk Punch, from the Eastern counties of England.
4. The Percheron or Norman, of Northern France.

Light horses:

1. The Hackney, of Yorkshire and Eastern England.
2. The Cleveland Bay, from Yorkshire, England.
3. The Standard-bred, of the United States, a trotter.
4. The Thoroughbred, or running horse of England.

THE LEGS AND FEET.—These are of most importance in a horse—"no foot, no horse" is true of it as of no other animal. The feet are constantly striking upon hard earth or stone. Why can a horse bear the strain of so much hard pounding upon its feet and legs? The parts are being constantly reformed; life is repairing them all the time. The different parts are put together with what we may call cushions. Then the parts of the hind legs are not joined in a straight line, and the front legs are not straight as the feet strike the ground. Step from a chair, keeping the leg stepped on perfectly stiff. Notice how the jar goes straight up through the knee to the body. When we jump we bend the knees.

SHOEING THE HORSE.—But the shape of the legs and the bending of the knees do not save the hoof from all wear and tear. If the shank and foot of a dead horse can be got, it will be an interesting study to take it apart and see the arrangement of the different parts. The wall of the hoof is what we see as the foot stands on the ground. It consists of toe, quarters, and heel. The wall turns in at the heel, forming the bars. Within the bars is the frog. Of what use is the frog? Should it be much cut down in shoeing? The varnish

The noon hour on the farm.

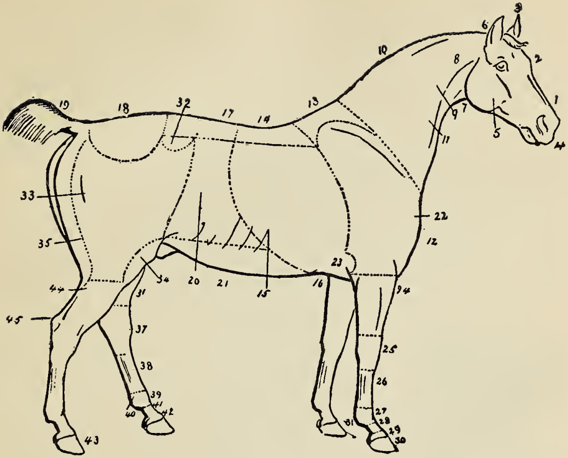


Fig. 54.

THE EXTERNAL PARTS OF THE HORSE.

1. Face.
2. Forehead.
3. Ears.
4. Muzzle.
5. Cheek or fowl.
6. Poll.
7. Throat.
8. Aarotid.
9. Neck.
10. Crest.
11. Jugular Channel or Furrow.
12. Breast.
13. Withers.
14. Back.
15. Ribs.
16. Girth.
17. Loins.
18. Croup.
19. Dock.
20. Flank.
21. Belly.
22. Point of shoulder.
23. Elbow.
24. Forearm.
25. Knee.
26. Canon or shank.
27. Fetlock joint.
28. Pastern.
29. Coronet.
30. Foot.
31. Ergot and fetlock.
32. Haunch.
33. Thigh.
34. Stifle.
35. Buttock.
36. Leg.
37. Hock.
38. Canon or shank.
39. Fetlock joint.
40. Ergot and fetlock.
41. Pastern.
42. Coronet.
43. Foot.
44. Lower thigh.
45. Point of hock.

on the hoof is formed by nature to keep the water out on damp ground, and to keep the hoof from drying up and cracking on dry ground. Should the blacksmith rasp off this varnish if it is the natural protection to keep the hoof sound? Great care must be taken in shoeing young horses while their hoofs are growing larger. On sod, turf, or dirt, it would not be necessary for a horse to be shod, as the hoof is hard, and formed by nature for running over the natural soil and grass. But we cause the horses to work on hard stone roads and pavements, and therefore we fit them with shoes that are harder than their natural hoofs. The hoof is of the same material as our finger-nails—we may call the hoof a large, thick toe-nail. The foot is the middle toe, the other four having disappeared. We can cut and pare the hoof and drive nails into it, therefore, without causing any pain. If we cut the nail too deeply, we come to a very sensitive part of the finger. So with the hoof; under it and within it is a very sensitive part of the foot. If we cut into it or drive nails into it, we cause great pain to the horse, and lameness and suffering follow. The horse, therefore, should always be shod by a good farrier or shoer. When you walk on your toes, or in a pair of boots too high in the heel or too tight, you soon tire out. If good shoes of proper form and weight are so important to us in walking, the proper fitting of shoes of the right weight and size is quite as important to the horse. This is another reason for always having the work done by a good workman.

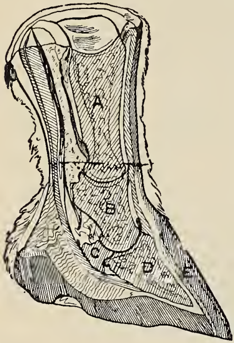


Fig. 55—The horse's foot: *A* is the pastern, *B* the lower pastern, *C* the navicular, and *D* the coffin bone; *E* is the wall of the hoof, to which the shoe is nailed.

Food of Horses.—The horse has a small stomach, and does heavy work, therefore we must remember that strong food and pure water should be given in moderate quantities, and at frequent intervals. The stomach when empty weighs from three to four pounds, and it will hold three to three and a half gallons. Horses are not built for coarse, bulky fodder. Nature and experience prove that such food as good hay and oats are well adapted to horses that have to work hard either in driving or in drawing. Overfeeding of ourselves makes us heavy and lazy, and causes indigestion. We should be careful to give the horse just enough to eat for its needs, and no more.

Care of Horses.—Grooming to a horse is the same as washing to ourselves—it keeps the pores of the skin clean and gives a good appearance to the horse. Since it does all of its work on its feet, the health of the feet and legs is of the greatest importance; therefore great care is taken in providing a proper floor for the stable. We do not rest or sleep well in a foul atmosphere; the horse stable should be kept clean and neat. We do not rest well on too hard a bed, neither does the horse. We do not thrive well when exposed to cold winds or heavy rains, neither does a horse. When we come in from hard work and are in a perspiration, we do not sit or stand in a draught; the horse is just as likely to catch cold.

What is meant by the height of a horse? In what terms is it stated?

When a horse walks, in what order does it lift its feet? Describe the actions of the feet and legs in trotting, pacing, cantering, and in galloping.

When a horse rises, which feet are raised first? Why does sitting on a horse's head prevent its rising? Would such action prevent a cow?

Is it natural for a horse to reach up and pull down its food, such as dusty hay?

CHAPTER XXIII.

CATTLE.

Breeds of Cattle.—Cattle formerly included all the live stock of the farm; we now apply the term only to bovine cattle or neat cattle. They are descended from wild animals, some of which are still found in the wild condition. As horses were at first used for warfare, cattle were largely used for work. We have now two uses for cattle—producing beef and producing milk. There are very many different breeds in these two classes, but we may give the four leading breeds of each class in this country as follows:

Beef breeds:

1. The Shorthorn, or Durham, originated in Durham County, England, over 100 years ago from Teeswater cattle. There are some dairy families also among shorthorns.

2. The Hereford, originated in Herefordshire, England, over 150 years ago.

3. The Galloway, a breed of black polled cattle or "doddies," from Southern Scotland.

4. The Aberdeen-Angus, from Aberdeenshire, Scotland.

Dairy breeds:

1. The Jersey, from the Island of Jersey.
2. The Guernsey, from the Island of Guernsey.
3. The Ayrshire, from Ayrshire, Scotland.
4. The Holstein, or Holstein-Friesian.

In figure 56 we give the outlines of a beef animal. We shall now refer to a few of these parts.

After the milking hour on the farm. Ayrshires and Jerseys.

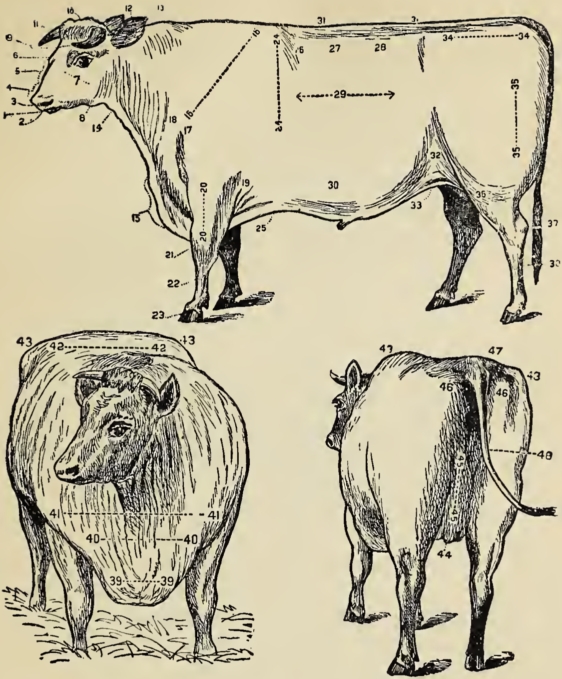


Fig. 56.—The External Parts of a Beef Animal.

1. Mouth.
2. Nostrils.
3. Lips.
4. Muzzle.
5. Face.
6. Eyes.
7. Cheeks.
8. Jaws.
9. Forehead.
10. Poll.
11. Horns.
12. Ears.
13. Neck.
14. Throat.
15. Dewlap.
16. Shoulders.
17. Shoulder Point.
18. Shoulder Vein.
19. Elbows.
20. Arm.
21. Knees.
22. Shanks.
23. Hoofs.
24. Crops.
25. Fore Flank.
26. Fore Ribs.
27. Mid Ribs.
28. Hinder Ribs.
29. Barrel.
30. Belly.
31. Spine.
32. Flank.
33. Plates.
34. Rumps.
35. Hips.
36. Thighs.
37. Hocks.
38. Hind Leg.
39. Brisket.
40. Bosom.
41. Chest.
42. Loin.
43. Hooks.
44. Purse.
45. Twist.
46. Pin Bones.
47. Tail Head.
48. Tail.

Horns and Hoofs.—The horns of cattle were intended by nature for defence. In the domestic animal they are not required, hence breeders have aimed at reducing or removing them. The "Longhorn" breed was once a favorite; it has given place to the "Shorthorn." In some breeds the horns have disappeared. These are called "polled" cattle, as the Polled-Angus and the Red Polls. The bone of an animal is largely made up of mineral matter (phosphate of lime), with some oily and gluey substances. Horns and hoofs are quite different from and independent of the bones. When burned, a piece of horn or of hoof will give off a very disagreeable odor. So will hair. The horns, hoofs, and hair are all nitrogenous in their nature. Since the horn is closely connected with a very sensitive part of the animal's head, when dehorning is practised, the horn should be cut off quickly and neatly. The horse's hoof is in one piece; the feet of cattle are cloven. Is there any advantage to the cattle in this? Which kind of foot is better adapted to climbing, and which to level travel? Do all cloven-footed animals chew the cud?

The Mouth.—When full-grown, we have three kinds of teeth. The front teeth are for biting, and are called the *incisors;* the back teeth are broad and double-rooted, formed for grinding, known as the *molars;* between these are longer teeth called the *canines.* If you examine the teeth of an ox, you find no upper incisors and no canines. There are eight lower incisors, and six upper and six lower molars on each side, making thirty-two in all, as follows:

$$\text{Incisors } \frac{0}{8} \quad \text{Canines } \frac{0\text{-}0}{0\text{-}0} \quad \text{Molars } \frac{6\text{-}6}{6\text{-}6}$$

This arrangement applies to cattle, sheep, goats, and deer, though sometimes canines occur. How would you represent, as above, the teeth of a boy and of a full-grown man? How those of a horse? The molars of a horse are larger and broader than those of a cow. A horse bites the grass with the incisors,

and by a nod of the head cuts it away. A cow wraps her tongue around the long, coarse grass, pulls it into her mouth, closes the incisors and upper gum upon it, and by a movement of the head tears it away. The horse is therefore able to take the fine grass, and to crop the pasture more closely than the cow.

THE STOMACH.—Sheep and cattle are ruminants—they chew the cud. See Fig. 57. *a* represents the gullet connecting the stomach and mouth through which the food passes into the stomach, and *f* the beginning of the intestine through which the food passes out of the stomach. There are four sacs all joined; *b* is the first or largest stomach (the rumen, or paunch); *c* is the second (reticulum); *d* the third (omasum); *e* the fourth (abomasum). When a cow takes in coarse food, it passes into the first or largest stomach until the cow is done eating. Then the cow stops taking in food and begins to digest it.

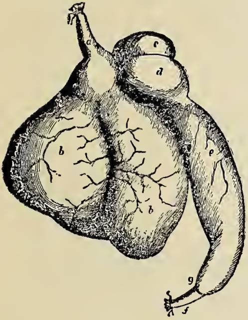


Fig. 57.—The four stomachs of a cow.

After soaking or steeping some time in the large stomach, it gradually comes back through the gullet to the mouth, to be chewed over and over until it becomes more liquid-like. Then it flows back and passes right on into the smaller stomachs, and thence into the intestines. If liquid food is taken, as in the case of calves, the food passes right on into the third and fourth stomachs. The four stomachs of the cow therefore enable her to take in a large quantity of food, and to digest very coarse fodder. The chewing of the cud enables her to do without the complete set of teeth so necessary in the case of horses. The single stomach of a horse holds about 3 gallons, the four stomachs of a cow from 60 to 70 gallons.

DAIRY CATTLE.—Figure 58 shows the general form of a good dairy cow, an animal in which the end desired is to give as large an amount as possible of rich milk at the least cost for food. Contrast the outlines of this animal with the one shown in figure 56. As a rule, the large dairy herds are com-

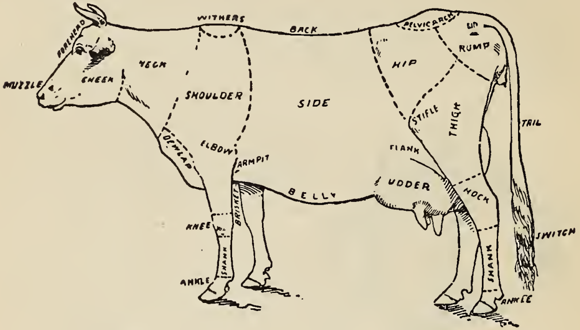


Fig. 58.—Parts of a model dairy cow (according to *Hoard's Dairyman.*)

posed of grade cows; these are the offspring of pure-bred sires and common dams. There is an old saying, "The sire is half the herd." This is illustrated in the following table of the offspring of a pure-bred sire and of a common (scrub) sire:

Pure-bred sire.	Common (scrub) sire.
Common cows or dams.	Pure-bred cows or dams.
1. Grades, one-half pure.	1. Grades, one-half pure.
2. Three-quarters pure.	2. One-quarter pure.
3. Seven-eighths pure.	3. One-eighth pure (scrub).

This statement means that in the first case we start with a herd of common cows and a pure-bred sire. The first generation of calves will all be grades, one-half pure-bred. The calves of these and the pure-bred sire will all be three-quarters pure-bred, and their calves will be seven-eighths pure-bred.

If, however, we were to start a herd with pure-bred cows and a common sire, the third race or generation would be only one-eighth pure-bred. The continued use of a pure-bred sire will in a few years bring the herd to the level of the sire.

Beef.—As we have got most of our farm animals from the British Isles, the names applied to them have come from the same source. The living animals we call oxen, cows, calves, sheep, swine, but the meat from these same animals we call beef, veal, mutton, pork. Why these two sets of names? In early times the living animals were tended by the Saxon hind, and the meat was eaten by the Norman lord or baron. Thus the names for the living animals are Saxon names, and the names for the meats are Norman.

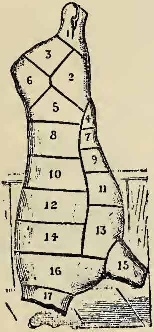


Fig. 59.—A Side of Beef.

1. Leg. 2. Round. 3. Mouse buttock 4 Veiny piece. 5. Sirloin. 6. Rump. 7. Thick flank. 8. Porterhouse (including tenderloin). 9. Thin flank. 10. Forerib. 11. Brisket. 12. Middle rib. 13. Shoulder. 14. Chuck rib. 15 Shin. 16. Clod. 17. Neck, or sticking-piece.

But what is the meat? It is made up of fat and lean meat. The lean meat is of the same composition as muscle; in fact, it is fine, tender, muscle fibre. Now we can easily understand why the different parts of a quarter of beef are not equally valuable. In some parts the fibre is coarser, more like muscle as we generally know it. We can understand why the neck is tough, and why the meat of the hind quarter, for instance, is tougher towards the smaller or lower part or shank. In finding the tenderest cut of the carcass, we look for that place where there is plenty of flesh and little work to be done, that is, where the muscles are least developed by hard work; this, by reference to Fig. 59, we locate between parts 5 and 8.

CHAPTER XXIV.

SHEEP.

"The foot of the Sheep bringeth wealth."

NATURE OF SHEEP.—Our domestic sheep are so harmless that we are not at first thought likely to see in them the descendants of wild animals. Their shyness, their flocking together and following a leader, and their natural inclination to climb hills and even knolls, recall the characteristics of their ancestors, the wild sheep of the mountains. They are more closely allied to our cattle than to other farm stock. Like the cattle they are cloven-footed, have four stomachs, and chew the cud. Cattle are more inclined to the wet bottomland and the water courses, sheep to the dry uplands. Cattle are coated with hair and sheep with wool. The sheep is one of man's earliest farm chattels, providing him with both meat and clothing, and is of very great usefulness in helping maintain the fertility of the soil.

Fig. 60.—What breed is it?

WOOL.—Hair and wool contain nitrogen, as you may prove by burning—ammonia being given off. Burn a piece of cotton thread and notice the result. The wool of the sheep is for its protection, and therefore the length and thickness of the wool vary with the climate of the countries in which the sheep are living. The same is true of the hair of cattle, as we see in the case of the shaggy covering of the Highland breed of cattle. Horses exposed to the winter weather grow a coarse coat. Food also affects the quality of the wool. If the food is not uniform the wool will become irregular and be of poor quality.

No other farm animal is so much affected by its surroundings as the sheep. As a consequence we find so many different varieties, and for this reason we must be careful to choose the variety that is most likely to do well in the conditions of the farm on which they are desired to be grown—such as situation, climate, etc. Why is wool warm? Because it is fine and open and holds so much air in its fibres, and this air prevents the heat of the body from going off; as we say it is a poor conductor of heat. It is not because it keeps out cold, but because it keeps in the heat of the body. If you wrap a piece of ice in a loose thick woollen cloth it will prevent the ice from melting rapidly. Why? Because the heat outside does not pass through or get in. Double windows in a house are a protection, not because of the glass in the panes, but because of the air between the two windows. So the hollow space in the wall of a silo keeps in the heat of the ensilage, and thus prevents it from freezing. A covering of loose snow protects the wheat for the same reason. Now that we understand that wool keeps the sheep warm while it is on the sheep's back, we ask why wool can be made into yarn and cloth. If you look at a fibre of wool under a magnifying glass you will see that it is made up of sections, that there are little joints or scales on the wool and when several fibres are twisted together these little scales catch into one another and the fibres thus hold together tightly—the wool, as we say, "felts" well. There comes from the skin of the sheep a soapy substance called the "yolk," which covers the inner wool and helps to shed the rain. It prevents the wool from felting on the sheep's body. When the fleece is washed this is washed out and the fleece becomes much lighter. Sheep are by nature fitted to stand cold, but not wet weather—they should always have dry quarters.

Breeds of Sheep.—Sheep of various breeds are found in Britain, from the marsh lands of Kent to the mountains of Wales and Scotland. They have adapted themselves in time

to a great variety of soil and climate, and in selecting sheep for a farm it is well to get the breed suited to the situation. The following is a table of the principal British breeds:

Mountain Breeds.	*Upland or Hill Breeds.*
Welsh,	Dorset,
Cheviot,	Southdown,
Highland.	Suffolk,
Lowland Breeds.	Hampshire,
Cotswold,	Shropshire,
Leicester,	Oxford.
Lincoln,	
Romney Marsh.	

The lowland breeds are long-wooled and the upland breeds short-wooled. The lowland breeds are larger than the uplands. The upland breeds are the best mutton breeds. Short wool from 3 to 4 inches long is sometimes called carding wool, and longer wool, from 7 to 8 inches long, combing wool.

The principal breeds of this country may be arranged as follows, according to the texture of their wool:

Fine-wooled:—Merino;

Medium-wooled:—Southdown, Shropshire, Hampshire, Oxford Down, Cheviot, Horned Dorset;

Coarse-wooled:—Leicester, Lincoln, Cotswold.

Is the wool on all parts of a sheep's body of the same texture?
Are all long wools coarse, and all short wools fine?
From what parts of Europe have the above breeds of sheep come?
At what time of the year does shearing take place?
Are goats covered with wool or with hair?
What kinds of cloths are made from wool?
Why is flannel cloth warmer than cotton?
What is shoddy?

CHAPTER XXV.

SWINE.

Nature of Swine.—The wild hog is still found in many parts of the world. Even in Europe there are districts where wild boars are hunted. From the many kinds of wild hogs our domestic breeds have been derived. In the wild condition the animal is very active, and well able to protect itself by its tusks and teeth. The improving of the wild animal has changed the form, and made an animal that is quite compact and fleshy, and less active. There is less bone in the hog than in sheep or cattle, as one may see from the following statement, which gives the number of pounds of water, fleshy substance, fat, and ash or bony matter in every 100 pounds of a fat ox, a fat sheep, and a fat pig:

	Fat Ox. lb.	Fat Sheep. lb.	Fat Pig. lb.
Water	48	46	43
Fleshy matter	15	13	11
Fat	32	38	44
Ash (bony part)	5	3	2

Thus it will be seen that a fat pig has more fat and less bone in proportion to its weight than a fat ox or a fat sheep.

Growth.—Although the hog has cloven hoofs, it does not ruminate or chew its cud as do the cow and the sheep. Therefore, we may conclude at once that it does not digest its food in the same way as they do. It has only one stomach. And yet we find that the hog grows in weight more rapidly. How do we explain this? There are three things to be considered: First, the kind of food which the animal eats; second, the means which the animal has of digesting its food; and, third, what the food, after being digested, is used for.

First, as to the food eaten. Pigs are able to eat a greater variety of foods than cattle or sheep. The wild hog lives on grass, roots, nuts, etc. Our domestic hogs are generally fed the richest kinds of food—peas, corn, wheat, skim milk, flesh meal, etc. Pigs will greedily devour the richest rations day after day of which most other animals would soon become tired.

Second, as to the power of digesting food. As we have stated before, the animal digests and takes up its food through the stomach and intestines. The pig has a small stomach, but a very long intestine. The following table gives an idea of the weight of the stomach and intestines in proportion to the whole body, and also the weight of the four quarters:

	Cattle. Per cent.	Sheep. Per cent.	Swine. Per cent.
Stomach...........	4½	2½	1⅕
Intestines....	2	2½	4
Four quarters.......	47½	45	73

Thus it will be seen that in cattle the stomach is over twice the intestines in weight, in sheep about equal, whereas in swine the intestines are over three times the weight of the stomach. We conclude that swine have small stomachs, and can take only a small amount of food at a time, but, because of their very long intestines, they are able to digest the food much more thoroughly—that is, they feed frequently and digest their food thoroughly.

Third, as to the use made of the food digested. They are not so active as sheep or cattle; they are generally more shut in, and therefore they do not use up as much of their food through exercise. English experiments prove that, out of every 100 pounds of digested food, cattle use 23 pounds, sheep 26, and swine 43, for making increase in their bodies.

When, further, we remember that swine increase in number so much more rapidly than cattle or sheep, we can understand why the keeping of swine is so profitable a part of farm work.

Breeds of Swine.—Every country has its own peculiar breeds of swine. In England there are, besides many others, the following: The Large White, the Small White, and the Middle breeds (so named according to their size and color); also the Black Suffolk or Essex, the Berkshires, the Dorsets, and the Tamworths. In America there have been developed breeds known as the Chester White (Pennsylvania), the Poland China (Ohio), and the Duroc or Jersey Red (New Jersey). The Yorkshires and Improved Yorkshires of America are derived from the Large White swine of England.

Feeding of Swine.—In producing pork and bacon, three things are to be noted: Selection of the right kind of swine; feeding the best kind of food; housing the animals in suitable quarters. In producing swine for bacon and hams that are required for city consumption, hogs of medium size, that produce lean meat and fat in proper proportion, are the best. Foods such as the bye-products of milk, peas, wheat, and barley, will produce more lean meat and less fat than corn. The hog is sometimes considered a dirty animal. For this the owner is as much responsible as the animal. Clean housing and good care will pay with swine as much as with other animals.

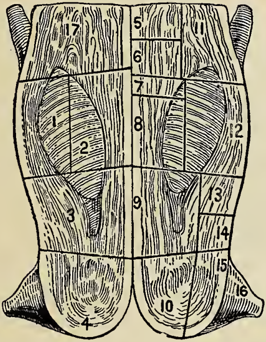


Fig. 61.—Two sides of pork, showing method of cutting up.

1 Streaky quarter.	9 Loin.
2 Rib quartet.	10 Fillet.
3 Middle quarter.	11 Shoulder.
4 Hams "	12 Prime streaky.
5 End of neck.	13 Thin "
6 Middle of neck.	14 Flank.
7 Thick back and sides.	15 Middle of gammon.
8 Prime back and ribs.	16 Knuckle of gammon.
	17 Fore end.

CHAPTER XXVI.

POULTRY.

ORIGIN.—In addition to the common poultry of the farm, we have turkeys, geese, ducks; also guinea-fowls, pea-fowls and pheasants. These are all closely related to various kinds of wild fowls and some of them are very similar to these wild fowls in appearance. In our common fowls there are very many varieties of breeds, from the small bantams to the large brahmas, differing in size, in shape, and in the color and form of feather or plumage. It is believed that all have been derived from one original source, a wild breed of fowl. Many consider that the common Jungle Fowl of India is the source from which have come all the varieties. This fowl is somewhat like the Black-breasted Red Game, and is still found in India. Others think a wild fowl now no longer found is the ancestor. How have our breeds been formed? Just as new breeds are now being formed. Suppose we take a flock of fowls and observe them from year to year, as they increase in number. We shall get some chickens that, as they grow, show differences in form, size and color. Even if they are all one variety, here and there one will appear having some slight difference from the others. We select two or three that have a new coloring in their feathers that we desire to continue. Those selected are different from the others, but similar to one another. We place them by themselves and allow them to breed. The chickens that we raise from them will probably have the same peculiar kind of feathers. We select those that are most alike and breed from them. After a few years we may be able to raise a number of fowls that are quite similar in appearance to one

another, but quite different from the original flock, and whose chickens will resemble the parent fowls. Thus a new variety or breed will be obtained. Or we may take birds from two different kinds of fowls and cross them. By carefully selecting only those that have the peculiarities that we desire to preserve, we shall soon get a new breed which may be improved in size and shape by selecting only the best, male and female, to breed from. Thus the Plymouth Rocks have been obtained by crossing American Dominiques with Cochins. It is very important to note that the fowls are so readily changed in form

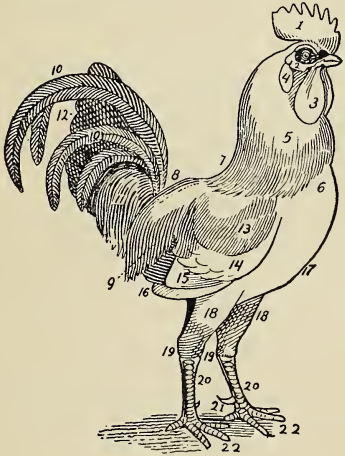


Fig. 62.— Parts of a Fowl.

1 Comb.
2 Face.
3 Wattle.
4 Earlobe.
5 Hackle.
6 Breast.
7 Back.
8 Saddle.
9 Saddle feathers.
10 Sickles.
11 Tail coverts.
12 Main tail feathers.
13 Wing-bow.
14 Wing coverts forming the "bar."
15 Secondaries.
16 Primaries, or flight feathers.
17 Point of breast bone.
18 Thighs.
19 Hocks.
20 Legs or shanks.
21 Spur.
22 Toes or claws.

and feathers. Breeds that are so readily changed will soon run out unless care is constantly taken to improve them, by weeding out the poorest and keeping the best with care.

THE PARTS OF A FOWL.—Since all have the same origin we may expect that they will all have some characteristics in common. The general form is the same. Fig. 62 gives us the names of the various parts.

VARIETIES.—In some varieties, such as the Cochins, the Langshans, and the Brahmas, the feathers extend down the outside of the legs or shanks. From this fact we sometimes have the fowls divided into the two classes, the *smooth-legged* and the *feather-legged*. The different breeds are further subdivided according to the color of their plumage; thus we have Dark Brahmas and Light Brahmas; also Black, Buff, White and Partridge Cochins. Another mode of classing fowls is into laying varieties and sitting varieties. Sometimes they are classed according to the country or region from which they have been derived, as Asiatics, Mediterraneans, Americans.

CHARACTERISTICS.—Common fowls have four toes, three in front and one to the rear. They are not web-footed, therefore we conclude they are fitted by nature for hard dry soil. What is the use of the web foot in ducks and geese? The toes have sharp strong nails for scratching. From this we notice that they should be supplied with a dry run where they can scratch and exercise themselves and their young broods. Fowls take their young to seek for food and birds bring food to their young in the nest. They need plenty of sunlight, as we may conclude from watching chickens basking in the sunshine. How do fowls drink water? Have they teeth? What is the use of the crop in fowls?

As to food we have only to remember what the fowls require food for to conclude that they need plenty of rich food. They are constantly growing feathers which are rich in nitrogen, their flesh is principally lean meat, their eggs are what we

call "strong meat." For their good health they need also some green food. The shells of their eggs are largely composed of lime, therefore we must give them mineral matter, especially when more or less shut in and when the ground is covered with snow. They are fitted by nature for picking out the richest food, such as insects and small seeds.

The health of the fowls depends greatly upon having a variety of clean food to eat, clean water to drink, clean places in which to roost and nest. The fowls keep their coats and skins clean of insects by dusting, as do many other animals.

Because of the rich food, such as grains and insects, which fowls feed upon, we may expect the droppings to be rich in fertilizing material. The richest manure made upon the farm is that from fowls. It should be carefully saved and used where it will do most good. The use of gypsum or sifted coal ashes about the hennery, especially under the perches, (not common lime or wood ashes) will keep the buildings clean and sweet. In washing the buildings with lime or other disinfectant, the orchard spray pump may be used.

Eggs.—A good flock of laying hens should lay on the average ten dozen eggs each. The egg consists of the shell, which is porous, the lining or membrane, the "white" or albumen, and the yolk.

Can you give any reason for some birds' eggs being nearly spherical in shape, and others oval like hens' eggs?

In which end is the air chamber of an egg?

Why is a stale egg lighter than a fresh egg?

What is meant by "candling" eggs?

Why is the shell porous?

Why does the setting hen turn the eggs under her?

What is an incubator?

How long does it take to hatch a chick from an egg?

Why does a "moulting" hen not lay eggs?

What are the principal methods of preserving eggs?

Which is the better test of a laying hen? The number of eggs laid, or the total weight of eggs laid?

CHAPTER XXVII.

MILK.

Milk.—Nature provides as a food for the young calf the milk of the mother cow. For a short time after the birth of the calf this product is called "colostrum." In a few days, however, the cow gives in her udder milk such as we use. The giving of milk is to a great extent an acquired habit. In the case of breeds raised for beef only, as in the case of Herefords, the quantity of milk given is not large. Where, however, the aim has been to produce dairy cows the continued practice of milking has gradually increased the flow of milk. The knowledge of this is important. For instance, if we begin by milking a cow, say for only six months, and then allow her to go dry, she will of herself be inclined to go dry thereafter at about the end of six months. If we do not thoroughly milk out a cow at first, she will gradually drop off in her flow. It is of importance, then, to thoroughly milk out the cows, especially as the strippings are the richest portion of the milk. Anything that irritates or disturbs a cow will cause her to "hold up" and to produce a poorer milk. The cow as a milk-producing animal, it must be remembered, is very much what her owner makes her, and she will give many of her qualities to her calf.

If we place some milk in a tall, narrow glass, and allow it to stand for a while, there will gradually rise to the top a thick substance, sometimes yellowish in color, which we call cream When this cream is churned, we get from it butter, which is an oily substance. Carefully remove the cream, and allow the other portion of the milk, the skim-milk, to stand for some time until it thoroughly sours; we shall find that a curdy

substance separates and leaves a bluish water behind. The cream or butter, then, is an oil or fat which is mixed through the milk, and from the fact that it comes to the top we conclude that it is lighter than the skim-milk. It is not dissolved in the water of the milk as sugar is dissolved in water, but is simply mixed with it or distributed through it in very fine particles; in fact, we can put it back into the skim-milk if we pour the two together from one vessel into another before the milk sours. It is in the form of what is called an "emulsion." When fresh milk is run through a cream separator, the heavy skim-milk is thrown away from the lighter fat or cream. This could not be done if the fat were dissolved in it. Milk, then, contains water and fat or oil—butter-fat, as it is called. Now take some skim-milk and slightly warm it. A thin scum forms upon it. This scum is composed principally of *albumen*, a nitrogen compound similar to the white of egg, which becomes white and insoluble by heating or cooking. It forms but a small portion of the milk. If, however, we put a few drops of rennet or vinegar into the skim-milk, a curdling at once takes place, and a considerable quantity of material is thrown out of solution and floats about as a curdy or cheesy mass; this is the *casein* of the milk, also a nitrogen compound. Then we have at least two nitrogen compounds in milk—the albumen, which is curdled by heat, and the casein, which is curdled by acids. The latter is in much larger quantity than the former, and both are in solution in the water of the milk. We can readily prove that these two contain nitrogen, and differ therein from the fat. Take some pure butter and burn

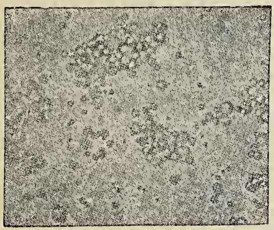


Fig. 63.—Milk, showing the fat globules floating in it.

it on the end of an old knife, then burn some casein curd or cheese, and notice the strong ammonia smell from the latter. If, now, we pour off the clean water from the curd, and carefully evaporate the water in a saucer placed over the steam of a kettle or in a slow oven, we shall get a white substance that tastes sweet but gritty; it is the sugar of the milk, called milk-sugar or *lactose.* Finally, if we carefully dry out a little dish of milk and burn it thoroughly, we shall have left a small quantity of ash or mineral matter. Milk, therefore, consists of water, having particles of butter-fat floating in it undissolved, and having in solution casein and albumen, milk-sugar, and ash. The composition may be stated as follows:

Water, from 80 to 90.......	averaging	87.0	per cent.
Fat, from 2 to 10..........	"	4.0	"
Casein or cheesy substance..	"	3.0	"
Albumen.................	"	0.5	"
Sugar or lactose..........	"	4.8	"
Ash or mineral matter.....	"	0.7	"

A pitcher of warm water gives off vapor into the air, but a pitcher of ice water will have vapor settle up its sides from the air. So it is with milk. Milk is warm when first milked and we can smell the odor, the cow odor, as it passes off into the air; but it soon begins to cool down and vapors of the air will settle upon its surface as upon the cold pitcher. If, therefore, we leave a pail of milk standing in the stable, or near any food that has a bad smell, it will take up foul air that can afterwards be tasted in the milk, the butter and the cheese. As soon as milking is done the milk should at once be taken to a clean milk-house or cellar. But bad odors and tastes can be given from the food. Thus turnips, bad ensilage, cabbage, rape and weeds of many kinds will affect the milk. All such should be kept from the animal. Here we see a strong argument for keeping pastures clean. Every trace of musty food such as mouldy ensilage or rotting roots should be kept from

the cows. The mangers should be kept sweet. No more food should be given than the cows will eat up clean, otherwise the feeding boxes may become stale. The best way to get good flavored milk is to feed only such foods as will give a good flavor. A plentiful supply of salt always within reach will improve the digestion, increase the eating power, keep the system in good condition, and increase the flow of milk.

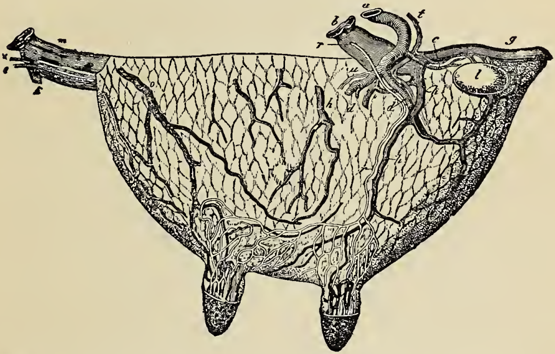


Fig. 64.— The udder, left side, with skin removed. *a* is an artery wi'h branches *c*, *d*, and *e* carrying blood to different parts; *b* is a vein with branches *g*, *h*, and *o*; *l* is a lymphatic gland; *m* is the milk vein; *t* is a nerve, of which *u* is a branch and *x* is a continuation. Beneath and connected with the above parts is a milk gland, the outlets of which are through these two teats. In the upper part of each of the teats is a small milk cistern. On the opposite side of the udder is a second gland having outlets through the two right teats. Out of the blood brought to the udder through the arteries, the cells next to the glands are formed. These cells are gradually changed into milk, which fills the glands and the milk cisterns, and passes off through the nipple of the teats.

CHAPTER XXVIII.

PRODUCTS OF MILK.

CREAM.—The cream is formed by the particles or globules of fat which, because they are lighter than water, rise to the surface. These globules are very small— it would take about 2,000 of the largest of them placed side by side to make an inch. To see them, they must be examined under a powerful microscope. Some of them are smaller than others. The larger they are, the more rapidly they will rise, and the more quickly and thoroughly the milk will cream. Milk with large fat globules is therefore adapted to butter-making; that with small fat globules is well adapted to cheese-making. These fat globules are not transparent; therefore instruments are sometimes used to determine the quantity of fat in milk by determining how much water must be added before the milk can be clearly seen through. Such instruments are called "lactoscopes."

The separating of the cream from the milk is done either by placing the milk in pans or cans, and allowing the cream to rise of itself, because it is lighter than the water; or by running it through a machine called a "separator." This consists mainly of a steel bowl, which is caused to revolve at a very high rate of speed. The water, being heavier, flies to the outside next to the bowl, and flows off by one spout, and the cream is left behind in the inner part of the bowl, and flows off by another spout. In order to allow the water and cream to separate more easily, the milk is warmed slightly before it is run into the bowl. The cream by this process is separated in

a fresh, sweet condition, whereas by the "cream-setting" process it may be more or less soured or ripened.

The richness of milk in cream varies greatly with the different breeds, the different animals of the same breed, the period of milking, and the portion of the milk taken. The strippings or last portions of the milk are richer in cream than the fore-milk or first portion milked, as the water comes away from the udder in larger portions at first, and the fat appears to be set free in the udder by the process of milking. Ordinarily cream will contain from 55 to 65 per cent. of water, 25 to 40 per cent. of fat, and some sugar and casein. If the milk sours during creaming, so as to cause the casein to curdle, more casein will be carried along with the fat. Therefore, the milk should be kept cool in creaming by the setting process. In creaming milk, the purpose should be to remove the butter-fat as thoroughly as possible, in as sweet a condition as possible, and with as little water as possible.

Skim-milk.—This is the milk that has been skimmed of its cream, or from which the fat has been removed by the separator. If we could take all of the fat, and only the fat, we would still have left in the skim-milk the water, casein and albumen, sugar, and ash. The skim-milk would contain a large amount of very important food compounds, viz.: casein and albumen, which can make muscle and flesh, or form fat, or be burned up to produce heat; sugar, which can be used for producing heat; and ash of the best kind for making bone. Thus we see that skim-milk is a most important food, only the fat is lacking to make it a perfect food for young animals. We can replace this fat that has been removed in the cream by mixing with it a small quantity of some oily food, such as a little boiled linseed. If, then, we take away the milk from the young calf for making butter, we can give it back to it by adding linseed or some rich meal to the warm skim-milk, and thus imitate the natural cow's milk. When the cream is

removed by the separator, the skim-milk is still quite sweet, but when we allow the milk to rise in shallow pans, or even in deep cans, the milk may become a little soured, unless we keep ice or cool water around it. When liquids become sour it is because of the forming of what we call an acid, like the acid of vinegar. The acid that is formed in milk when it first sours is called lactic acid (from the latin word *lac*, meaning "milk"). This lactic acid is formed from the sugar of the milk or the *lactose*. Since the sugar is very soluble, any water that goes off in the cream will contain lactose, so that lactic acid will form also in cream. This acid at once acts upon the casein, changing it from a soluble substance to an insoluble substance; therefore, as soon as acid begins to form, the milk will begin to curdle. This lactic acid is not nearly so valuable for food as the sugar from which it is formed; therefore, sweet skim-milk and sweet whey are always more valuable for feeding than sour milk or sour whey, and care should be taken to keep them as sweet as possible. But why does milk sour? What causes the sweet sugar to change to the sour acid? You know that yeast causes bread to "work" or to ferment. The yeast is a mass of little plants, each plant very simple and very small. These plants feed upon the substances in the dough, changing them and making new compounds, some of which are gases. These gases push out in all directions, and make little air-holes all through the bread, causing it to be light, as we say. Now, yeast is only one kind of these minute little plants. They are found everywhere floating about in the air by millions, too small to be seen. Some of them, we have already stated, grow in little knots or balls on the roots of clover and peas.

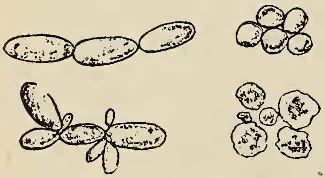


Fig. 65.—Yeast plant, magnified.

Some of them are acting constantly in the soil, changing some of the humus into nitrates for the roots of plants. Some of them gather on cheese and form blue-mold. Some of them get into the refuse barrels and cause decay of the pieces of food thrown therein. Some of them drop into the cider or wine and make vinegar. There are very many kinds, each kind working in its own way. They can be recognized only by a very powerful microscope. One kind, that is very common, drops into the milk and changes the sugar into lactic acid. Supposing that we do not clean out a milk pail or a milk can thoroughly, what will happen? Many of these little ferments, or *bacteria*, as they are called, will settle on the sides and get into the cracks, and just as soon as milk is placed in the vessel they will begin to act upon the milk, causing it to sour rapidly, or to produce substances that have a nasty taste or an unpleasant odor. If there is any trace of milk left in the can after the milk is poured out, they rush down upon it and begin to feed and increase in number. Any dirty places about the floor, or table, or walls, will also cause them to greatly increase. Tainted milk is not pleasant to drink, it makes poor butter and poor cheese ; so that for success in dairying everything must be kept clean, *very clean*—the cows, the food, the stables, the pails, the utensils, the milk house, and the dairy workers. One of the great reasons for using ice and cold spring water to keep the milk, cream, and butter sweet is because these little ferments cannot do harm in very cold places. They do their work only when they are kept moderately warm. Science, then, teaches us that in dairying it pays to be clean. In addition to ferments which may get in from the outside it is thought that there are minute forms of life somewhat similar to these ferments, which are contained in the

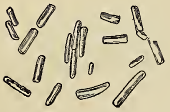


Fig. 66.– One of the ferments of milk, magnified.

milk itself. These work changes in the milk and milk products when the conditions are favorable.

Butter.—We have referred to the use of the separator for obtaining sweet cream from the fresh, warm milk. A machine made on a similar plan is capable of so throwing the particles of fat together that they come out, not in the form of cream, but of fine butter. This machine is called an "extractor." The butter made from it will, of course, be sweet cream butter. Ordinarily, however, the cream is obtained either by the separator, by setting in shallow pans, or by setting in deep cans placed in ice water. Then the cream is allowed to ripen. This ripening is caused by some of the little ferments that were referred to before. These get in from the air, or they may be placed there by taking a little cream from some that has already ripened, just as we may take some dough that has already worked and place in a fresh lot of dough to start it working. At once these ferments begin work, and produce changes that give a new taste or flavor and a new odor to the cream. If we allow the cream to stand too long, or in a foul atmosphere, some ferments will get in that will produce unpleasant taste and foul odors. These little ferments, then, help us in our work, or they can spoil our work. We must, therefore, learn the methods which will give us the best ferments to assist us and keep out the bad ferments that will hinder us. If the milk or the cream is first warmed for a few minutes the ferments in the milk will be killed—the milk will be "pasteurized," as we say. Then the right kind of ferment is added, and the ripening of the cream takes place. By this method the making of butter is under the perfect control of the dairyman, and butter of uniform quality is produced.

The cream, well-ripened, is placed in the churn, and the action of the churn throws the little particles of fat together, until soon we have them gathered into little masses; the butter begins to come in little grains; these grains gather into large

lumps, and soon the buttermilk can be drawn off. The butter is washed in the churn with cold water, and then turned out and worked and salted. The buttermilk contains some lactic acid and casein, both of which, if left in the butter, would be further acted upon by ferments, and disagreeable compounds would be formed; therefore, the buttermilk is carefully drawn off, the washing is thoroughly done, and the working of the butter drives off the last traces or almost the last traces. The working of the butter, then, is to take out the rest of the buttermilk, but it must be done carefully, so as not to break the tiny grains of the butter and rub them into an oily mass. Then the salting—what is it for? Salt, we know, preserves food. It attracts moisture, the moisture of the buttermilk, and it prevents the ferments from going on with their work. By all this process we have got rid of nearly all the casein, sugar, and ash; we have still some of the water; and we should have all, or nearly all, the butter-fat that was in the milk. Any sugar, or acid, or casein that is left, will in time be likely to set the ferments at work and make the butter rancid or stale.

BUTTERMILK.—Since cream varies so much, according to the system of getting the cream, the buttermilk will vary a great deal in composition and value. It should contain very little fat if the churning has been properly done, less than one per cent. It will contain a little ash, quite an amount of lactic acid, and some casein. The casein will vary with the system of creaming. As a food, it should be used as soon after churning as possible, before further fermenting is set up.

CHEESE.—In making butter, we try to take all the butter-fat, and only the butter-fat, out of the milk; in making cheese, we try to take all the casein and the fat out of the milk. If we were simply to take the casein out of skim-milk, we would get what is called a skim-milk cheese, or a skim-cheese. Usually, however, whole milk is used, and a great many different kinds of cheese may be made. The milk of goats and of ewes is

sometimes used, but the cheese of this country is made almost entirely from cows' milk. Formerly, the cheese was made in the private dairies, but now principally in factories, to which the milk is drawn. The cheese usually made here in the factories is what is known as Cheddar cheese. It is more properly called American Cheddar, or Canadian Cheddar.

The fat, as we already know, is simply floating in the milk in fine particles, but the casein is held in solution. To get it out of the milk it must be changed to an insoluble form. Rennet is the substance used for this purpose. This is an extract obtained from calves' stomachs. If a little rennet is dropped into a glass of milk, the casein will at once begin to appear as a flaky, curdy substance with the fat entangled in it, and the water may be poured off, leaving behind the casein and fat. In the factory, the milk is strained and run into large vats that have a larger vessel or jacket around them for holding water or steam. By means of this jacket the milk can be cooled or warmed, as the maker desires. The rennet is added, and at once curdling begins; the proper heat is obtained by hot water or steam, and the curdy milk begins to "ripen." Gradually, by working, the flakes or grains of curd increase in size, and when the proper time comes the water is run off. This water or whey carries away the sugar of the milk and most of the ash material; little or none of the fat should float away on it if the cheese-making has been properly done. The curd is heaped up and allowed to drain, when it appears as a crumbled mass. Some salt is added and mixed with it; then it is run through the mill, and is ready for putting up in packages. These packages are pressed out and bandages are put on them, when they are taken to the curing room. The curing of the cheese is a very important part of the making. The room is kept at a warm temperature, and various ferments work in the cheese, causing changes that add much to the flavor and food value of the cheese. The fresh, or "green,"

cheese is not nearly so tasty or so digestible as the matured or well-ripened cheese. If the cheese is allowed to remain exposed to the air it will mold, and its value will be greatly decreased. Its rich flavor depends largely upon the cream of the milk and the changes that take place both in the ripening in the vat and in the after-ripening in the curing-room.

WHEY.—If we remember that the whey contains the sugar of the milk, most of the ash, and some of the albumen, and casein, and fat, we shall conclude that it contains some food of value. But this value depends upon its being used while "sweet," before it sours, for then its sugar changes to lactic acid, which is not of much value. As a food, it is specially adapted to the feeding of pigs. One of the greatest difficulties about cheese factories arises from the souring of whey. As before stated, success depends upon keeping the factory, the factory yard, and the milk cans absolutely clean.

We may sum up the various dairy products as containing the following:

Whole milk contains water, fat, casein, albumen, sugar, ash;
Skim-milk contains water, casein, albumen, sugar, ash;
Butter contains water and fat principally;
Cheese contains water, fat, casein;
Whey contains water, sugar, ash, some albumen.

The average composition is about as follows in every one hundred pounds:

	Water.	Fat.	Casein and Albumen.	Sugar.	Ash.
Whole milk...	87.0	4.0	3.5	4.8	0.7
Skim-milk....	90.0	0.5	3.0	5.0	0.7
Butter........	10.0	86.5	1.0	0.5	2.0
Cheese	35.0	33.0	28.0	0.0	4.0
Whey.........	93.0	0.3	1.0	5.0	0.7

CHAPTER XXIX.

THE STRUCTURE OF ANIMALS.

Plants and Animals.—What is the difference between a plant and an animal? It is sometimes very difficult to determine whether some of the lower forms of living matter are plants or animals. In the higher forms the distinction is easily made by us. What is the difference? A horse requires air, water, and food. So does a tree. The horse takes in oxygen from the air and breathes out carbonic acid gas; the tree takes in carbonic acid gas and gives out oxygen. The horse can move about at will to seek food; the tree remains fixed, and the food comes or is brought to it. The horse feeds upon plants—organized food; the plant feeds upon crude material, such as mineral compounds—unorganized food. The plant, therefore, is built up from the simple substances in the air, soil, and water. The animal builds itself up largely by feeding upon the material formed by the plants. This distinction, however, does not hold in the case of all plants and all animals. Can you state any exceptions to the above?

Bones.—These are the framework or foundation. They largely make the general form of the animal. The bones of a young animal are pliable, but they become more rigid as the animal grows older. They are the support of the animal, but to enable the animal to move, they are in parts joined together. Notice how every bone is suited to its place. The skull covers the top and back of the head, thereby protecting the brain. The ribs, front and back, protect the heart and lungs. Why are they not closely joined together, as the bones of the skull? The bones are suited in size and length to the uses required

of the various parts of the body, as may be seen in the bones of the arm and the fingers. The bones are composed of mineral material, phosphate of lime being the principal constituent. In structure, they are more or less porous or cellular.

Muscles.—The bones are ingeniously joined together in many places, but to hold them together and to move them muscles are required. In some places these are large and tough, in others they are smaller and more tender. The lean part of an animal's body is a mass of fine muscle fibres. Feel their movement on the inside of the wrist while closing the fist. Grasp your upper right arm, then move the lower right arm up and down. We observe that the muscles that do the most work are the strongest and largest. These muscles are in all parts of the body, crossing and overlapping. By contracting and expanding them the animal moves the bones, and therefore the part of the body containing the bones. Around them and over them we sometimes find layers of fat which act as a sort of packing.

The Organs.—In addition to the ordinary muscles, there are the tongue, the throat, the stomach, the heart, the lungs, the liver, the kidneys, the intestines, etc. These are different in shape and different in their uses, but all are very much like the muscles and tendons in composition—they may be called structures of muscles formed together into certain definite shapes, so as to do certain definite work. The skin, the hair, the wool, the hoofs, and the horns, that is, the outer parts of an animal, are also made up of the same kind of material as the flesh and muscle.

Blood.—"The blood is the life." It flows through all parts of the body, and it is out of it that all the various parts—bone, muscle, organs, lean flesh, fat—are formed. When we examine blood under a microscope we find that it somewhat resembles milk, as shown in figure 63, page 133. First of all, there is the liquid part, which is called *plasma*. In this plasma

are floating a large number of small disc-shaped particles, which are called *corpuscles.* Most of these are red, and thereby give a red color to the blood. Some are white corpuscles. It is by means of these corpuscles that much of the material is carried through the system. For instance, in the lungs they take up a load of oxygen and carry it to all parts of the body and bring back a load of carbonic acid gas to be breathed out from the lungs. In the plasma is contained much of the material that goes to build up bone and flesh. We have seen that when the albumen of milk or white of egg is heated it becomes insoluble, or is clotted. When acids are added to milk, the casein becomes clotted. In plasma there is a similar nitrogenous substance, *fibrin*, which is clotted by the action of the air. When blood flows from a cut, therefore, the clotted fibrin and the corpuscles that are entangled in it form a covering for the wound—otherwise the animal would bleed to death. When a clot forms inside of the body, circulation stops at that point, and death frequently results. In a man the blood forms about one-thirteenth of his entire weight.

Conclusion.—Apart from the water of the body, the various digestive liquids and agents, and the blood, we have, then, three classes of compounds in the animal body—the bones; the fat; and the muscles, the various organs, lean flesh, hair, hoofs, and horns. The bones, as we have already stated, are largely made up of ash or mineral matter; the fat contains three chemical elements—carbon, hydrogen, and oxygen; the third, or muscle class, is made up of five elements—carbon, hydrogen, oxygen, nitrogen, and sulphur. To show in what proportion these are contained in an animal's body, we give one example. The body of a half-fat ox, after the removal of the stomach and intestines, will contain in every 100 pounds the following: Water, 56 pounds; flesh and muscle material, 18 pounds; fat, 21 pounds; bone material, 5 pounds.

CHAPTER XXX.

FOODS OF ANIMALS.

USES OF FOODS.—First of all, an animal requires food to build up its body—to form bone, flesh, muscle, organs, skin, hair, wool, fat, etc. The material for all these must be contained in its food or the water it drinks. In the next place, it requires food, or fuel, to keep it warm, to supply heat to the body. Then it requires food to keep it alive—a horse shut up in the stable without food for a single day will suffer. This food is necessary to replace the waste constantly taking place. The body is constantly changing, and requires food to renew it, whether the animal is working or standing still, whether sleeping or awake. In the fourth place, work demands food. An engine at work demands a supply of energy—this comes from the burning of the fuel under the boiler. A horse moving about or doing work requires food to supply energy. These four demands are made upon the food which is daily given to an animal, and the food given should be chosen so as to supply these demands. We have on page 148 a table of the composition of the principal foods given to animals. This table is simply for reference, and is given in order to get a general idea of the great difference in the various foods used.

WATER.—We see that green grass, roots, and fodder corn all have a large quantity of water—from 75 to over 90 per cent. (that is, pounds per hundred)—whereas hay, straw and grain have only from 12 to 16 per cent. Young plants that are cut while still green are therefore succulent foods and are eaten by animals in large quantities. As plants grow older and mature, the amount of water that they contain gradually decreases.

Composition of Foods.

	Water.	Albuminoids, or Protein.	Fat or Oil.	Starch and Sugar.	Woody Fibre.	Ash.
Milk, whole	87	3.5	4.0	4.8		0.7
Milk, skimmed	90	3.8	0.5	5.0		0.7
Linseed	12	21	36.0	19.5	8.0	3.5
Oil Cake (old process)	9	30	10.0	36	9	6
Oil Cake (new process)	10	34	3.0	39	10	7
Oatmeal	8	15	7.0	67	1	2
Cottonseed Meal	8	40	13.0	26	6	7
Pasture grass	65	4	1.0	18	9	2.5
Meadow Hay, average	13	6	2.5	45	29	4.5
Red Clover, average	15	12	3.0	39	25	6.0
Wheat Straw	10	3.5	1.3	43	38	4
Oat Straw	10	4.0	2.3	42	37	5
Pea Straw	10	7.0	2.5	35.5	40	5
Corn Stalks	40	4.0	1.0	33.0	20	2
Wheat	11	12	2	73.0	2	2
Barley	11	12.5	2	69.5	3	2
Oats	11	12	5	60.0	9	3
Corn	11	10	5.5	70.0	2	1.5
Peas	11	20	2.0	53	12	2.0
Bran	12	15	4	54	9	6.0
Middlings	12	15	4	61	5	3
Mangels	90	1.5	0.2	6.3	1	1
Turnips	90	1	0.2	6.8	1	1
Carrots	90	1	0.4	6.6	1	1
Potatoes	80	2	0.1	17.9	1	1
Corn Silage	80	2	1	10.0	6	1

Albuminoids.—Compounds like albumen or white of egg, the casein of milk, the gluten of wheat, and the fibrin of meat, are known as *albuminoids* or *protein.* They are all compounds containing nitrogen, and are the flesh-forming substances of food. They are very low in roots, a little larger in grass, still larger in hay; so that we see that they increase as plants mature. They are very low in straw, but quite large in grain. Why is this? As the wheat, oats, and other plants are growing they take up food from the air and soil and, until blossoming time, all their food is contained in the leaves, stalks, and roots. After blossoming the seeds form, and material that has been stored in the stalk and leaves is used to build up the seed. In most plants very little valuable food is taken into the plant through the roots after the time of blossoming. The leaves continue taking in carbon and the roots water, and therefore starch and sugar continue to increase, but the other substances are about all in the plant by the time of full bloom. Out of the leaf and stalk the most valuable materials are then carried into the seed; thus we find the nitrogenous compound, the fats or oils, and the most valuable ash compounds, especially the phosphates, stored up in the seed or grain, and not in the straw.

Fat.—For the reasons just given we must look for fat or oil principally in the grains. Some seeds, such as flaxseed, contain a very large amount of oil.

Starch and Sugar.—These materials are very much alike in composition; they are composed of three elements—carbon, hydrogen, and oxygen. Hydrogen and oxygen, we have learned before, are the two elements composing water. These two are found in starch and sugar in the same proportion as in water, but not as water, and therefore such compounds are sometimes called "carbo-hydrates." They are found in large quantities in all plants and parts of plants, forming as

much as 70 per cent. of some kinds of straw. Notice that this class of compounds does not form one of the leading classes of constituents of the animal body.

FIBRE.—Woody fibre this is sometimes called. A young plant is easily bent and pulled to pieces; it contains little fibre. As the plant grows older it becomes stiffer and tougher, because the fibre increases. Wood that we burn is nearly all fibre, and we know how tough and indigestible it is. Therefore, we conclude that a large amount of fibre makes a food less valuable. The fibre is formed from the starch and sugar by the addition of carbon. It forms the walls of the cells of plants, and therefore is sometimes called by the name "cellulose.'

ASH.—The ash or mineral matter is found in all parts of the plant, but, as has been stated already, the most valuable ash is stored up in the seed or grain. The cell walls of the plant fill up with carbon and ash as the plant grows older, and therefore the sap cannot flow through so easily, the cells dry up gradually, and the plant becomes stiffer and tougher.

REFERENCES :—

The teacher who wishes to study the subject matter of this chapter further may consult "Feeds and Feeding," by Henry, "Cattle Feeding," by Armsby.

CHAPTER XXXI.

DIGESTION AND USES OF FOOD.

WHAT IS DIGESTION?—The food which the animal eats must pass into and become part of the blood before any use can be made of it. The fuel which keeps it warm or supplies energy to enable it to do work; the compounds which go to the building up of bone, muscle, flesh, organs, wool, and all other parts of the body; the material out of which milk is made—all these come from the blood. This material in the blood is made up from the food which the animal eats. The blood may be called a liquid flowing through the body containing the material in solution. But the solid portion of our food consists to a large extent of such substances as starch, sugar, fat or oil, nitrogenous compounds, such as the gluten of wheat, the white or albumen of egg, and the fibrin of meat. Of these sugar only is soluble. It is necessary, therefore, to change these insoluble parts of food into soluble forms so that they can pass into the blood. This changing them into soluble forms in the various organs of the animal's body is "digestion." The changes are brought about in the mouth, in the stomach, and in the intestines, and the agents that cause the changes are *ferments* somewhat similar to the minute forms of life already referred to in the curing of cheese, and nitrification in the soil (see pages 138 and 139).

There are three forms of compounds in the food to be digested—those similar to starch (the carbohydrates), the fats or oils, and the nitrogen compounds (the albuminoids). These we shall refer to as we follow the course of digestion.

THE COURSE OF DIGESTION.—The food is first bitten off and taken into the mouth, where it is cut up and ground fine by the teeth. At the same time a liquid called the *saliva* is set free from glands in the cheeks and under the tongue. This saliva not only moistens the food so that it can slip down the throat or gullet, but it also acts upon the starch, converting it into sugar, thus changing it from an insoluble to a soluble form. Thus digestion begins in the mouth. Thorough chewing of the food not only breaks up the food fine so that it can be acted upon by the juices of the body, but also helps to set free saliva and mix it with the food to digest the starch. When we remember that starch forms a very large portion of most of our vegetable foods, we see that thorough mastication the food is very necessary to good digestion, and "bolting" the food by man and many other animals a common cause of indigestion.

The food passes from the mouth into the gullet, which is a tube formed of tough elastic rings that can contract and expand as required. Through the gullet it passes into the stomach. Here it comes in contact with the *gastric juice*, which is a secretion of the stomach. The gastric juice acts principally upon the albuminoids, changing them into soluble forms. Some of the soluble and digested food here passes into the blood, but most of it goes on through into the intestines. Just below the stomach, and on the right side, is the liver, which builds up or secretes a liquid called *bile*. This bile flows into the intestines and acts upon the fat of the food, forming with it soluble compounds. Other secretions come in contact with the food, acting upon the albuminoids and starch to complete the digestion; and through the walls of the intestines the soluble foods now pass in large quantities into the blood. The rest of the food that cannot pass into the blood moves on and is expelled from the body, forming the solid excrement. The solid excrement therefore consists of the

insoluble portion of the food, that which could not be digested by the secretions of the mouth, stomach, and intestines, and any soluble matter that was unable to get into the blood because of the animal being fed too rapidly or in too large quantity. Its value as a fertilizer will therefore depend upon what we feed and upon how we feed. It may be worth much or very little.

At this point it will be worth turning back and reviewing what has been said about the four stomachs of the ruminants (cattle and sheep), the small single stomach of the horse and the pig, and the long intestines of the pig.

Circulation of the Blood.—The next question is as to the movement of the blood through the body—the circulation of the blood. We start at the heart, which is the headquarters of the blood system, the pumping-station of the system. The heart is made up of muscles which expand and contract and thus give motion to the blood. When the heart stops beating, when it ceases to work, the animal life stops and death takes place. We can feel the beating of our heart. On the inside of the wrist we can feel the throbbing of our pulse. On the side of the head between the ear and the temple we can feel the same throbbing. Where do you find the pulse of a horse, and the pulse of a cow?

You have doubtless seen an ox heart; if not, try to get one and examine it. In shape it is like a large pear or egg. There are two divisions, one up and down and one across, dividing it into four compartments. The two smaller divisions in the upper or larger part are called the right and the left *auricle*, and the two larger lower parts are called the right and the left *ventricle*. The different parts of the heart are connected with tubes that go to all parts of the body, and the four compartments are connected by valves. By the movement of the muscles of the heart the blood is driven along. How is its course directed or controlled? Perhaps you have seen a mill-

race or a small canal with a swinging gate that will open in only one direction. When the water rushes against it one way it opens the gate and passes on; if it rushes back it shuts the gate and thereby stops itself. So in the heart, the valves open only in one direction, and the tubes of the heart have valves that allow the blood to flow in only one direction. Thus by means of these automatic or self-closing little gates the course of the heart's blood is controlled and the circulation is always properly directed.

Now let us very briefly follow the course of the blood. It comes from all parts of the body into the right auricle through two veins, whose valves open only towards the heart. The heart contracts and the blood flows into the right ventricle through the opening, whose valve opens only towards that ventricle. From the right ventricle it goes by an artery to the lungs, where it gets a supply of fresh oxygen from the air and where it gives up its load of carbonic acid gas to be breathed out into the atmosphere. Thus purified it comes back by the veins to the left auricle. Then it passes to the left ventricle. From the left ventricle it is forced out of the heart through the arteries and is carried to all parts of the body. These arteries divide and sub-divide until they become a network of fine tubes called the capillaries. These capillaries uniting again form the veins which carry the blood back again to the right auricle. Thus every beat of the heart sends fresh blood out to all parts of the body, and the old blood comes back to be purified before being sent out again through the arteries. The veins are the tubes that carry the old blood to the heart; the arteries are the tubes that carry the fresh blood from the heart. We see, therefore, why the cutting of an artery is much more dangerous than the cutting of a vein. In cutting an artery we open up the flow direct from the heart—the sluice-gate is opened for the free flow of the blood.

With the stomach, and especially with the intestines, are

connected a large number of capillaries. Into these flow the dissolved portion of the blood. After passing through the liver system the material is carried in one of the veins to the heart (the right auricle).

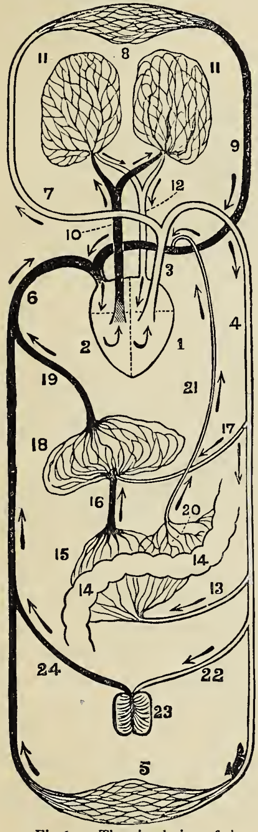


Fig. 67.— The circulation of the blood in the body.

In Figure 67 we have a condensed and modified illustration showing how the blood circulates through the body. The arrows show the direction of flow. The black channels are the veins, and the unshaded the arteries (except Nos. 10 and 12). 1 is the left side of heart; 2, the right side; 3, the aorta from the left ventricle; 4, artery to abdomen; 5, capillaries; 6, vein from abdomen; 7, artery to head; 8, capillaries; 9, vein from head; 10, artery from right ventricle to lungs; 11, the lungs; 12, vein from lungs to left auricle; 13, artery to intestines; 14, small intestine; 15, capillaries and veins from intestines carrying away digested food; 16, portal vein; 17, artery to liver; 18, liver; 19, vein from liver; 20, lacteals; 21, duct leading to vein going to the heart by which some absorbed material is taken into circulation; 22, artery to the kidneys; 23, the kidneys; 24, vein from the kidneys.

Thus we have seen how the digested food gets into the blood, and how the blood is carried through all parts of the body. The next question is as to what is done with this blood.

Uses of the Digested Food.—The animal must be kept warm, and therefore some food is required as fuel. The oxygen of the air comes in through the lungs and unites with the material in the blood, or with material such as fat formed from the blood. To keep warm, therefore, food and fresh air are necessary. Now you will understand why brisk walking, running, or working in fresh air, even in cold air, will cause you to become warm, especially if you have been well fed. It is like starting a fire with plenty of good dry fuel and opening the draughts. Then there is bone to be built up in one place, muscle in another, wool or hair in another. If the animal is growing, food is necessary; even if it is not growing food is necessary, for the old parts are constantly wearing away and new parts being formed. If the cow is giving milk, the material of the milk must be formed out of the material in the blood. If the horse is doing hard work there must be material in the blood to replace the muscle that is being worn away, and also to be used up to produce the force or energy that we see resulting in work.

The Waste Material.—In the burning up of food to produce warmth, in the using up of food to produce work, in the working over of material to form flesh, muscle, fat, bone, wool, or milk, there will, of course, be more or less waste or refuse material. How is this refuse material got rid of by the animal? In three ways: by the lungs, by the skin, and by the kidneys.

The Lungs.—Animals breathe in pure oxygen and breathe out carbonic acid gas and moisture. They should therefore be able to get pure air and not be compelled to breathe over again the air that has already come from their lungs, for it

contains some refuse of their bodies. If we shut up an animal in a close room it will smother. The animal must have fresh air. Proper ventilation is necessary for the good health of all animals. Exposure to cold draughts, however, must be carefully avoided.

The Skin.—The small capillaries come out close to the skin, which is filled with pores or tiny openings. We may say that animals breathe through their skin, and through the pores of the skin rid themselves of a large amount of used-up or refuse matter. We help the animal, therefore, by keeping its skin clean. When we curry or rub down a horse or a cow we do for it what we do for ourselves in taking a bath. A clean skin is necessary to the health of an animal. We should keep in mind that every pore is the outlet of a little drain whereby the refuse of an animal is carried out of its system. If these little drains are choked up sickness may follow; if they are kept open the system is helped very much in its cleansing process. The regular and proper currying and brushing of a horse means more work from the horse; the currying and brushing down of a cow means more milk. Cleanliness always pays. Science and practice are agreed upon this point.

The Kidneys.—The blood in its circulation goes to all the organs of the body, building them up and supplying material for their various uses. All parts of the body are constantly changing; some quite rapidly, as the brains; some quite slowly, as the bones. The old portions that are being replaced have to be removed. We have just above stated that through the lungs and skin carbonic gas and water are constantly being thrown off. But there are many other substances, such as the nitrogen compounds and the mineral compounds, which cannot escape by way of the lungs and skin. How are these got rid of? The kidneys, which in human beings lie below and behind the stomach, near the back, are

the organs that do this work, freeing the blood from these refuse compounds and passing them off in the liquid excrement or urine. This liquid excrement, then, is a solution of material that comes from the blood, muscle, bone, etc., of the body, and, therefore, we may conclude it will contain valuable fertilizing material, more valuable as a rule than the solid excrement. The liquid excrement consists of the dissolved waste of the blood, muscle, bone, and other parts of the body; the solid excrement consists of the indigestible and undigested portion of the food. None of the waste nitrogen or mineral matter of the animal escapes from the body through the lungs, but all passes off through the kidneys. Hence the great importance of carefully saving, by litter or otherwise, all the liquid excrement for use as a fertilizer. When we sell grain, hay, straw, and roots, we take away from the soil of the farm all the nitrogen and mineral matter which they contain, we really sell part of the soil upon which these foods grew. When we feed these to stock and sell the animals or their products we sell but a small portion of these soil constituents; by far the larger portion is found in the solid and liquid excrement. The economy of feeding stock upon the farm lies then in the saving of all the excrement, especially the liquid, and returning it to the soil upon which the plants originally grew, and from which we wish to derive more food.

Conclusions.—The uses of food in the animal may now be stated briefly as follows:

1. To produce heat to keep the body warm.
2. To produce force or energy to enable work to be done.
3. To replace the waste from all parts of the body.
4. To increase the body in bone, muscle, flesh and fat.
5. To produce milk, wool, etc.

Every animal must be kept warm. Every animal does some work or uses up some energy even when standing still or lying down; all parts of the body are constantly wearing away and

being reformed. Therefore, first of all, food must be given for these three purposes before any increase in fat or flesh takes place, before any hard work is done, or before products such as milk are obtained. It is only from the *excess* of food that the fourth and fifth uses can be supplied. When we wish an animal to work hard, to increase in flesh and fat, or to produce milk we must feed liberally. Poor feeding, therefore, will give us no return at all beyond keeping the animal alive, but liberal feeding must be done where we wish to get some return.

Care of Animals.—If we leave animals out exposed to rough weather we shall have to increase the food to supply heat; if animals are compelled to work hard to get their food or are restless and excited, they must use up more food. The proper housing and protection of animals will save food, and the keeping of them in quietness and comfort will also cause a saving. Thus we see that good care means a saving of food for the first two requirements mentioned before, and is quite as important as proper feeding; in fact good care is one of the most important parts of good economical feeding. Good feeding implies the selection of the foods suitable for the wants of the different classes of animals, the preparing of the food in suitable and attractive forms, and the proper care of the animals during and after feeding.

PART VI.

CHAPTER XXXII.

BEES.

BEES.—We can carefully observe a bee on a thistle top or a roadside flower. It will not harm us if we do not disturb it. There are two pairs of wings very thin, like a membrane, hence the bees are said to belong to the order of *hymenoptera*. When not flying, these wings fold in closely together; when flying, they spread out and the inner pair hook or hinge on the outer pair, so that the bee is able to carry a heavy load. Perhaps we can see the long tongue which it can thrust away down into the cup of the flower to take up the juice or nectar. This little tongue can be twisted about as an elephant twists its trunk, and it has a sort of brush on the end with which the nectar is swept up. The nectar or sweet juice of the blossom is carried up into the mouth and from there it passes into a little sack called the honey-bag. When its honey-bag is full it goes home to store away this honey. If we could see its legs under a magnifying glass we would notice that they are hairy and have some hollows along the side. What are these for? We have before learned that the blossoms of flowers produce pollen. Some of this pollen the bee needs for food, and the pollen is carried home in the hollows of its hind legs. Some

Fig. 68.—A bee gathering nectar from a blossom.

of the pollen will cling to other parts of the bee, and so, when it goes from one flower to another, it frequently carries this pollen to blossoms that have none of their own or that cannot use what they do have. The bees (and other insects also) in this way help to make plants fruitful, to fertilize them as we say. But there is another part of the bee that we shall find out before we desire to do so if we anger or disturb it, namely, the sting. It is found in the rear end of the abdomen, and consists of two long sharp lances. It can be pushed into one's hand but cannot easily be drawn out. When the bee cuts into the flesh it throws into the cut a drop of poison through the lances with which it pierces. It leaves the sting in our flesh, causes us pain because of the poison, and itself soon dies. We may then conclude that bees will not readily sting, but do so simply when disturbed and as a last resort in self-defence.

THE HIVE.—We go to the hive and there we find perhaps 20,000 of these honey gatherers, or "workers" as they are called. Inside, if we can look through a glass side, we see one larger bee surrounded by a dozen or so of the others. This is

Fig. 69. Drone. Queen. Worker.

the Queen or mother bee, whose duty it is to lay eggs. There is only one Queen. After once settling down as the mother of the hive she never goes out except when "swarming," but day after day lays eggs, as many as 2,000 in a single day. Then we observe some others that do no work, so far as we can see, they are the "drones." The family or swarm then will consist of one Queen bee, 20,000 or more workers, and

500 to 1,000 drones. The Queen is the female or mother that lays the eggs, the workers are females that gather the nectar and do the work, and the drones are the males.

THE COMB.—Next we observe the comb. It is made up of hundreds of cells in which the honey is being packed, and in which young bees are being hatched. In shape they are six-sided. Why six-sided? If you draw a lot of circles touching one another there will be some vacant spaces between. If you draw squares or triangles you can fit them closely together, but there will be sharp corners to fill in. Now if you draw a lot of regular six-sided figures you can fit them all together, there will be no vacant spaces, and no sharp corners. Cells of that shape will be strongly built. In fact you cannot improve on the shape of the cell which the bee makes. The comb is made up of wax, bees-wax we call it. The bees make this out of honey, but it takes some time, and therefore bee-keepers help the bees in their work by starting it for them. They make the beginnings or foundations of the combs for the bees. These foundations are put in, and when completed by the bees can be easily taken out separately. This is one reason why we get much more honey from our hives than we would from the wild hives of the bees where they have to be constantly making the whole cells for themselves.

Some of the cells are used for storing honey and pollen, and some are used by the Queen bee for hatching out the young bees. The egg is laid in the cell by the Queen. Then the workers place beside it some jelly made up of honey and pollen to be used as food. In about three days the egg hatches and a little larva appears. This feeds and grows, and in about six days fills up the cell. Then the bees put a cover or lid of wax thread on the cell, the larva goes into the second or pupa stage that we have noticed in connection with other insects, and in about twelve or fourteen days the perfect bee appears and comes out of the cell a worker bee. The

cells in which the drone bees are hatched are a little larger and the time to form is a few days longer. When a queen bee is required a different process is needed. Perhaps the old Queen has died or is going away with a swarm to form a new home. A larger cell than either of the others is made, the egg is laid, and a special kind of food called "royal jelly" is placed within. In less time than before the young Queen bee appears. Thus it takes about 16 days for the Queen to be produced, 21 for a worker, and 24 for a drone. There are many things in regard to the production of these three classes of bees that cannot be explained.

Honey.—The bees can gather honey only while the flowers are in bloom, therefore they work rapidly and store up large quantities for winter food. In an ordinary hive a colony of bees will put away from 50 to 100 lbs. The bee-keeper at the end of the season takes out part of this for his own use, leaving enough for the use of the bees until the next flowering season comes around. But what is the honey? The bee takes the nectar or juice out of the flower; in its honey-bag some slight change probably takes place, and in the cell, before being capped over, more change occurs. But just how nectar becomes honey as we know it, cannot be fully explained.

Bees gather honey from many different plants that blossom at different times of the year, and the honey varies in quality according to its source; thus we have clover honey, thistle honey, basswood honey, buckwheat honey, golden-rod honey, etc. In fruit blossoming we find the bees in large numbers in the orchard, and, as before stated, spraying with poisons, such as Paris green, should be discontinued while the trees are in full bloom.

Kinds of Bees.—Just as we have common cattle and also pure-bred that have been improved by care, so we have different kinds or varieties of bees. They are generally named according to the country whence they come, as English, Italian,

Syrian, Cyprian, etc. These differ just as much as Shorthorns, Jerseys and Ayrshires. Some are quiet, others are very ill-tempered. In addition to our honey bees there are other kinds of bees, such as the humble-bee, whose tongue is long enough to get into the nectar of the red clover. We have here given only a very few of the simplest facts in regard to bees. There is no part of nature that will be found more interesting or more profitable than the study of the busy bees.

Swarming.—In the fall of the year the wild bees complete their store of honey, packed away usually in a hollow tree. As the weather grows colder the bees go out less and less. Winter sets in and we find the bees all bunched together, clinging to one another in a half-asleep mass, a drowsy bunch that can be handled without any fear of stinging. On bright, warm days some of the bees may venture out for a while. In this dormant condition they eat but little. Spring comes on and the early flowers appear. The hive again becomes active and the hatching of the young brood begins. The old queen, with a part of the bees, starts off to seek a new home, leaving the old home for the new queen and her followers. Swarming takes place, the bees fly away in a cloud and settle in a tree probably. The bee-keeper is on the watch, he follows them and shakes them down into his basket, and places them in an empty hive, where they soon take up their regular work of storing honey.

Suggestive :—

Should the fruit grower keep bees? Why?

Name some useful honey-yielding plants. How does "clover honey" differ from "buckwheat honey"?

CHAPTER XXXIII.

BIRDS.

"And the birds sang round him, o'er him
'Do not shoot us, Hiawatha!'
Sang the Opechee, the Robin,
Sang the Bluebird, the Owaissa,
'Do not shoot us, Hiawatha!'"—LONGFELLOW.

MIGRATIONS OF BIRDS.—As winter goes and the warm spring begins, the buds show life and the grass shoots up. Then we look for the return of the birds. They come back to us at first two by two, or in small flocks. Sometimes we see great flocks flying past, high over head, steering straight north for the regions where they may find food and nesting places. They went far south to escape the winter's snow and cold, and they come back to us to build their nests and rear their young. A few of the fliers may stay with us all winter long if they find their natural shelter, but most of them fly south in the fall and return in the spring. We look for their coming as we look for the spring, and we are never disappointed, though year by year we see many changes. Some birds are missed and new kinds are welcomed. The bluebirds, for instance, may disappear for a few years. We think they have been driven out or destroyed. If our eyes and ears are trained, however, we may see and hear them passing to new fields further north, flock after flock of thousands passing by overhead in the early morning.

USES OF BIRDS.—Sometimes we think they do more harm than good, and we are apt to call them a nuisance. But how we would miss them! If their singing and chattering were completely silenced, we would soon wish for their return; and

we would long for a sight of them in their varied form and coloring, even if they did not sing for us. Many of the wild birds, the game birds, of course, supply food for man, and their usefulness no one questions. But, apart from their singing and their beauty of form and color, of what use are the other birds —the robins, the bluebirds, the yellow-birds, the blackbirds, the woodpeckers, the blue jays, the meadow larks and the very many other birds of our gardens and fields? That depends on what they feed upon.

Food of Birds.—Many birds are fond of fruit and will take some of the cherries and berries of the garden, others will help themselves in the grain field. This, however, does not prove that they are a nuisance and should be destroyed. As a rule the birds feed upon the food which is most readily got—weed seeds, fruits, or insects. If fruit is plentiful they will take some fruit, but if insects are about they will greedily pick them up and in quantities that will astonish us. Birds that feed upon insects are called "insectivorous." Most of our common birds are more or less insectivorous, and while they do some injury by robbing the fruit trees, berry-bushes and grain fields, they do far more good by devouring great quantities of insects that if allowed to live would inflict most serious injury. The only way that this can be proven by you is by carefully watching the birds as they go about through the garden, or as they carry food to their nestlings. On examining the stomachs of many birds that are supposed to be the most destructive to fruit, large quantities of destructive insects have been found. If the birds do take some fruit it must be remembered that as a rule they pay well for all they take. It may be set down as a safe rule that most of our birds do more good than harm, and our aim should be to encourage them, and not to destroy them. It has been estimated that one bird will devour or destroy about 2,400 insects in a year. Even the English sparrow, blackbird, and crow are known to destroy large numbers of

insects. Birds of prey, such as the hawks and owls, destroy large numbers of field mice and other vermin that are very injurious to growing crops and stored grain.

Protection of Birds.—There are some birds that appear to be very destructive. Some hawks are much dreaded because they kill young chickens; the crow blackbirds, or bronze grackles, are the bitter enemies of many of our common birds, and crows have few friends because they pull up the sprouting corn. They take the corn at that time because it is softened in the soil and can then be eaten by them. Even crows, however, feed largely on insects when insects are to be got. The English sparrows, also, have made themselves very much of a nuisance because they nest about the houses and barns and steal oats from the field. Even these three kinds of birds make up for some of their badness by destroying insects. One of the most objectionable birds is the cow bird or cow blackbird, which is a parasite, that is it lays its eggs in the nests of birds smaller than itself. The true owners of the nest are pushed out by the intruder when hatched. What we need to learn, however, is that we should protect most of the birds rather than destroy them. Some try to encourage the birds to nest by setting up small houses, placing empty boxes and cans in the trees, hanging pieces of twine and hair upon the fences and limbs The general rule that we should follow is—leave the birds alone, do not molest or disturb them, keep away from their nests. They will soon learn that they can come and go in safety and build their nests and rear their young broods without fear, and year by year they will return to their old nesting-places and will repay us for their assurance of safety. The birds are the farmers' friends, but they must be treated as friends.

How many birds can you name and describe?

What birds frequent the fields, and what birds are found along the streams and small lakes?

Make a list of all the birds of your locality under these heads:—Those that make their nest in the grass; those that nest about the house and barn; those that nest in the orchard trees; those that nest in the foliage of forest trees; those that seek a hollow in the tree.

What birds of your locality rear two broods in one season?

Which are the best singers of your birds?

What is the difference between a bluebird and a bluejay? Between a blackbird and a crow blackbird? Between a wren and a greybird? Between a cedar bird and a grosbeak? Between a barn swallow and a field sparrow? Between a robin and a Baltimore oriole?

"It is well known that of the various groups of birds the majority live upon insects. Among the insect eaters are the fly catchers, warblers, woodpeckers, nuthatches, orioles, goat suckers, hummingbirds, tanagers, waxwings, gnatcatchers, kinglets, vireos, thrushes, wrens, titmice, cuckoos, swallows, shrikes, thrashers, creepers and bluebirds.

"It is not generally known, however, that the so-called seed-eaters feed their young largely upon insects, and eat a great many themselves; nor is it realized how much good they do by eating weed seeds. Professor F. E. L. Beal has calculated that the little tree sparrow in Iowa alone destroys 1,720,000 lbs. of noxious weed seeds every year. Moreover, in summer seed-eaters eat blueberries, huckleberries, strawberries and raspberries, and distribute their seeds unharmed over thousands of acres which would not otherwise support such growth.

"After the examination of about forty birds, the only one actually sentenced to death is the English sparrow. Of all the accused hawks only three have been found guilty of the charges made against them—the goshawk, Cooper's, and the sharp-shinned—while the rest are numbered among the best friends of the fruit grower and farmer. Of the woodpeckers, the sap-sucker and redhead may be beneficial or injurious, according to circumstances, but the rest of the family are highly beneficial. To most of the remaining birds tried the evidence is decidedly creditable. The crow, crow blackbird and cedar bird are acquitted, as doing more good than harm; and it is proved that agriculturists owe especial protection and friendship to the phœbe, kingbird, catbird, swallow, brown thrasher, rose-breasted grosbeak, house wren, vireos, cuckoo, oriole, shore lark, loggerhead shrike and meadow lark."

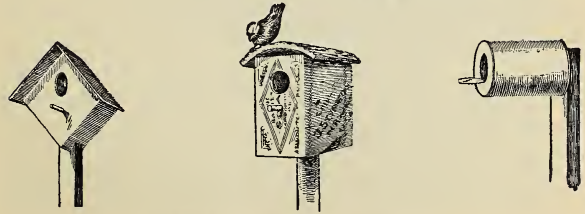
FLORENCE A. MERRIAM, of Washington, D.C.

"Within certain limits, birds feed upon the kind of food that is most accessible. Thus, as a rule, insectivorous birds eat the insects that are most easily obtained, provided they do not have some peculiarly disagreeable property. It is not probable that a bird habitually passes by one kind of insect to look for another which is more appetizing, and there seems little evidence in support of the theory that the selection of food is restricted to any particular species of insect, for it is evident that a bird eats those which, by its own method of seeking, are most easily obtained. Thus, a ground-feeding bird eats those it finds among the dead leaves and grass; a fly-catcher, watching for its prey from some vantage point, captures entirely different kinds; and the woodpecker and warbler, in the tree tops, select still others. It is thus apparent that a bird's diet is likely to be quite varied, and to differ at different seasons of the year.

"The practical value of birds in controlling insect pests should be more generally recognized. It may be an easy mattter to exterminate the birds in an orchard or grain field, but it is an extremely difficult one to control the insect pests. It is certain, too, that the value of our native sparrows as weed-destroyers is not appreciated. Weed seeds form an important item of the winter food of these birds, and it is impossible to estimate the immense numbers of noxious weeds which are thus annually destroyed.

"If birds are protected and encouraged to nest about the farm and garden they will do their share in destroying noxious insects and weeds, and a few hours spent in putting up boxes for bluebirds, martins and wrens will prove a good investment. Birds are protected by law in many states, but it remains for the agriculturists to see that the laws are faithfully observed."

PROF. F. E. L. BEAL, B.S.,
Asst. Ornithologist, Dept. of Agriculture,
Washington, D.C.



Build houses for the birds. Nesting boxes,

CHAPTER XXXIV.

FORESTRY.

"But I behold a fearful sign,
To which the white man's eyes are blind;
Before these fields were shorn and tilled,
Full to the brim the rivers flowed;
The melody of waters filled
The fresh and boundless wood;
And torrents dashed and rivulets played,
And fountains sported in the shade.
These grateful sounds are heard no more,
The springs are silent in the sun,
The rivers, by the blackened shores,
With lessening currents run.
The realms our tribes are crushed to get
May be a barren desert yet."

—*Bryant.*

The Primeval Forest.—What was the appearance of North America four hundred years ago, when it was first discovered by Columbus and by Cabot? Let us turn to a map of the continent. Along the west coast we have the great mountain ranges, beginning at Alaska and continuing south through Mexico. These were covered with thick forests, in some places the trees being of enormous size. A large portion of this great primeval forest still remains untouched, especially in British Columbia. Then notice the mountain ranges on the eastern side. As they cross into Canada they become lower, branching into two sections, the one going north-east through Labrador, and the other north-west through Ontario. In between these two branches lies Hudson Bay. This

What does the picture illustrate? Are all kinds of maple equally useful as sugar-making trees?

whole eastern section was covered with a dense forest, extending from Florida to the bleak lands of Labrador and away off north-west towards Alaska and the barren lands. It covered all of the Eastern States, the eastern provinces of Canada, all of Quebec and Ontario, and a part of the North-west Territories. Down through the central part of the continent stretched the prairies, treeless, except on the hills here and there, or along the rivers.

Much of this original eastern forest has been cut away by settlers or killed by forest fires, but some still remains in the mountainous parts of the Eastern States and in the northern parts of Maine, New Brunswick, Quebec, and Ontario.

Range of Forest Trees.—This great forest of eastern North America was composed of many varieties of trees, each variety growing where it thrived best. In some places they were mixed, as though scattered by mere chance; usually, however, the different kinds were confined to certain districts where the conditions were favorable. Thus we here and there come upon a white pine belt; in one place we find a forest of maples, in another, oaks or elms. As climate and soil are the two things that largely control or determine forest growth, we may expect to find the various kinds of trees confined to certain limits. If we trace across the country a line marking the places up to which each kind of tree is found growing, but beyond which it will not grow in any very large numbers, we shall thereby get lines which mark what are known as the "northern limits" of these trees. These lines will not run east and west, nor will they parallel in all places. The Atlantic and Pacific oceans and the inland lakes and Hudson Bay have the effect of making them very irregular.

DESTRUCTION OF THE FOREST.—What has destroyed this great forest? First of all, the settler had to clear the soil for his roads and for his fields of grain and of pasture. In early days of settlement two of the principal products of the farm were the logs and timber from the body of the trees, and the ashes made from burning the top branches and small cuttings. To-day the cutting of lumber is removing year by year large numbers of trees, but the natural growth of young trees is more than sufficient to make up for this cutting, if properly carried on. The great agent of destruction to-day is fire. One forest fire will sweep away or destroy, in a few weeks in summer or autumn, far more than all the lumbermen remove. The fire burns rapidly because of the inflammable material, such as resin, in the evergreens. At the same time it destroys the young sprouting seedlings and the seeds also, which would otherwise soon start a new forest, that in twenty-five to forty years would replace the old forest.

FOREST AREAS IN THE CANADIAN WEST. — This is peculiarly a prairie region. Nature, in consequence of insufficient moisture, or on account of fires, has been sparing in her timbered lands, and man's carelessness and need are rapidly depleting the little that we have left. Our fuel supply is moving further and further away, and the price of wood is growing yearly greater.

Can anything be done to arrest the depletion?

One instance will furnish a sufficient answer. Germany has made phenomenal progress in the matter of tree-planting. This was a feature of the policy of Frederick the Great, by means of which Germany was to be raised from a small and consequently weak power to a great nation. The wisdom of this policy is now evident. Where once sandy deserts would not nourish a flock of

goats, vast armies have been maintained, and regiments of hardy soldiers have poured from districts where, two hundred years ago, the thorn and the thistle overspread the impoverished land.

What has been done for Germany can be done for the Western plains.

Benefits of Forests.—Trees are the glory, the beauty and the delight of Nature. Light, shade, shelter, freshness and repose are all there.

Things in nature, too, are related. This is a common saying, but like many other common sayings it is seldom taken seriously; the reason being indifference or ignorance as to the actual nature of the relationship.

The farmer's business, more than any other, perhaps, depends for its success upon a true estimate of and a careful regard for this inter-relation. He adapts his crop to the nature of the soil, and the manner of its cultivation to the changes of the seasons. In a word, he shapes conditions, and places them in their proper relation to each other and adapts himself to them.

Now, soil, moisture and heat, are the three factors which, if properly related and utilized, combine to produce good crops. This is just as true of trees as it is of wheat. In some directions these factors can be more or less readily controlled, in others the farmer is apparently helpless. He can maintain the fertility of the soil. How? He can remove surplus water. How? He can even so manage the process of evaporation as to provide his crop with the bulk of two seasons' moisture. How? He can do all this and more, if he is an intelligent member of his profession; but, the rainfall and the temperature, and the changes of the seasons, the very factors upon which his success depends, are beyond his direct control. Still he

can modify them by indirect means, and he can study how to make the greatest use of them when they present themselves; and this is the greatest problem in the whole of agriculture, and will continue to be the greatest problem—the problem of how best to manage the supply of moisture.

One of the most effective means of dealing with this question lies in the proper distribution of forest areas.

Whether or not forests increase the amount of precipitation in their vicinity is still a debated question, although there are indications that under certain conditions large, dense forests may have such an effect. This much may be said—the water transpired by the leaves is certain in some measure to increase the relative humidity of the country near the forest or forest belts, and thereby increase directly or indirectly the water supply in the neighborhood. But, while no increase in the amount of rainfall may be secured by forest areas, the availability of whatever falls is increased by a well kept and properly located forest growth. The bed of the forest is a widely spread surface, piled thick with leaves, twigs, branches, and remnants of decayed and decaying logs, covering another layer of the same substances in a state of partial decomposition, overlying yet another stratum completely decomposed, altogether forming a hollow framework, penetrated with myriads of pipes, tubes, and channels, and interspersed with millions of miniature logs, blocking and holding in position the flow of water, until the humus below fully absorbs it. The large and perpendicular tap-roots, possessed by many trees, pass deeply into the solid clay strata and send through the earth a slow and steady supply of water, which, travelling away from the forests and under the cultivated fields, supply the great lower bed of moisture,

that, constantly rising, continues to fertilize the upper soil.

All these conditions operate together. The foliage, twigs, and branches break the fall of the rain drops, and the moisture is conserved because of the reduced evaporation in the cool and still forest air, being well protected from the too great moisture-dissipating agencies, the sun and the wind. The protection thus afforded by the forest against the escape of moisture from its soil by superficial overflow and evaporation insures the permanence and regularity of streams and springs. To destroy the forest of a mountain slope is to devote the height to barrenness, the valley to flood, and both to parching drought.

Another means by which a forest belt becomes a preserver of moisture lies in its wind-breaking capacity, by means of which both the temperature and the velocity of winds are greatly modified, and evaporation from the fields to the leeward materially reduced.

On the prairies, wind swept almost every day and every hour, the farmer has learned to plant wind breaks about the buildings, and has found in them a desirable shelter from the hot summer winds and the cold winter gales. The fields are usually left unprotected, and yet a wind-break on the side of the prevailing winds would bring an increased yield.

Not only is the temperature of the winds modified by passing over and through the shaded and cooler space of a protecting timber belt, but their velocity is greatly reduced, and with this their power as evaporating agents. Thus more moisture is left for the use of the growing crop.

It is estimated that every foot in height of a forest of medium thickness will protect at least one rod in distance, and several belts in succession would probably greatly increase the distance.

On the sandy plains where the winds are apt to blow the sand, shifting it hither and thither, a forest belt placed in the proper position is one of the most effective, if not the only means of protection.

Mention has already been made of the damage resulting from the removal of forests from the sides and tops of hills. In this Western land there are many hills that are gradually being washed away by rains, and thus not affording fit soil for cultivation. Covering such hills with a suitable forest growth would render them a blessing instead of a menace. This is the very work that is being done at present in certain countries, where the hill tops were unwisely denuded of their only natural covering.

In order to be thoroughly effective, the forest growth must be dense, and the forest floor must not be interfered with by removing the litter of leaves, burning the undergrowth, or allowing herds of cattle to compact it. When once established and properly managed the wood lot will attend to its own planting. How?

The Forest as a Producer of Crops.—If the trees are a crop, how should that crop be harvested? We cut down all of a wheat crop at one time. If we are growing a crop of corn for green ears we do not pick all at once, but go over the field again and again, taking the ears that are full-grown and leaving the small ears to grow larger. If we were to cut down a whole forest or a wood, as we do a crop of wheat, we would have to wait many years for a new crop. But if we take out each year only the largest trees, and leave the others standing until they grow to full size, we can harvest a crop of trees every year, and at the same time assist the smaller trees to grow more rapidly. The cutting down of trees, large and small alike, is wasteful; the proper cutting of trees, leaving the young

forest to make growth, is alone worthy of the name of forestry.

The Forest Tree Nursery.—Every farm should, and every school might, have a small nursery, a plot fenced off so that cattle and pigs cannot get into it, and which should be as well tended as a flower garden. Here are the instructions of a forester, who is an authority on the subject, Sir Henri Joly, Lieutenant-Governor of British Columbia: "With a little attention, it is easy to tell when the seeds are ripe. Thus, toward the end of June and early in July the seeds of the elm and those of the plane are ripe; if you sow them at once, they will shoot up nearly a foot that same summer. The seeds of the maple, ash, oak, wild cherry, and walnut mature in the autumn; it is better to sow them immediately than to keep them in the house all winter. Sow, let us say, maple seeds half an inch deep, and others in proportion to their size, two or three inches for nuts. Sow thickly, and after the first year you can thin them by transplanting some. After four or five years you can plant your young trees where they are to remain. You should select cloudy or rainy weather in the spring.

"In many cases you can even spare yourself the trouble of sowing. When the ground is favorable in July or August, along the ditches, the woods, the fences, in the moss, in damp places, in the neighborhood of the elms and the planes, you will find hundreds of little shoots which have sprung from the seeds fallen from the trees; plant them in your nursery.

"The seed of the pine is very difficult to gather. Early in the spring, in the pastures near the pines, you can pull up, when the soil is damp, as many little trees as you will wish to plant; for this kind it will be better to take the

precaution to shelter them from the sun until they have taken root."

From this nursery you can set out a row of maples or elms along the main road and the lane, taking care to keep them well apart, so that they will branch out and not shade the road too much ; you can also plant a windbreak for the house and the garden ; you can cover the hilly ground and protect all springs and water courses ; you can also plant a small clump in a corner of the pasture, being careful to protect it from the cattle until well grown ; you can locate a few trees near the house, but not too near. There will be no difficulty in finding a place for every tree, and, if properly cared for, every tree thus set out will add to the value of the farm or the home.

Planting the Trees.—The main life organs of a tree are, as you are already aware, the roots and the leaves. The trunk and branches serve to carry the crown upward and expose it to the light, which is necessary in order to prepare the plant food and increase the volume of the tree. These also serve as conductors of food materials up and down between root and foliage. A large part of the roots, too, aside from giving stability to the tree, serve only as conductors of water and food material ; only the youngest parts, the fibrous roots, beset with innumerable fine root hairs, serve to take up the water and minerals from the soil. These fine roots, root-hairs and young parts, are therefore the essential portion of the root system. A tree may have a fine vigorous root system, yet if the young parts or fibrous roots are cut off or allowed to dry out, which they readily do — thereby losing their power to take up water, such a tree is likely to die. It may be

stated, as a probable fact, that most transplanted trees which die soon after planting, do so because the fibrous roots have been lopped too closely, or else have been allowed to dry out on the way from the nursery or the forest to the place of planting. They were really dead before being set. Evergreens are particularly sensitive in this particular. Maples and oaks will stand, on the other hand, a good deal of abuse. Hence, in transplanting, the first and chief care, besides taking the sapling up with least injury, is the proper protection of its root-fibres against drying out. Never, therefore, allow roots to become dry, from the time of taking up the tree until it is transplanted. To prevent drying during transportation, cover the roots with moist straw or bags, or leave on them as much of the original soil as possible.

The ground that is to receive the plants should be carefully ploughed and harrowed and the holes for the trees prepared. These holes are best made before the trees are brought to the grounds. They should be a little deeper than the depth of the root system, but larger round than seems necessary, to facilitate penetration of rains and development of rootlets through the loosened soil. Place the top soil, which is better than the subsoil, to one side, and the raw soil from the bottom to the other side. In filling back bring the richer soil to the bottom. Why? Keep all the stones out of the bottom and place them above. The hole should be made to suit the particular root system, not the root system made to suit the hole.

The time for planting depends on climatic and soil conditions, and the convenience of the planter. Spring planting is preferable in the West, where the winters are severe and the fall apt to be dry, the soil therefore being in an unfavorable condition. Why?

CHOICE OF TREES.—Trees for school grounds, yards, and along roadsides and streets, may be such as are least liable to suffer from injuries; they should be compact and symmetrical in shape, free from objectionable habits and from insect pests, and if planted for shade should have a broad crown and a dense foliage. Absence of skilful hands at the planting on Arbor Days would also limit the selection to those which are transplanted the most readily, and which require a subsequent minimum amount of care.

Trees native to the region have usually more promise than those imported, and their characteristics may be made an object of study, before concluding to remove them.

After the planting is done keep the ground free from weeds and grass, and prevent it from baking, by an occasional use of the hoe or rake. Trees are not benefited by being used as hitching posts and climbing poles.

When forest plantations have become a settled thing, the Western farmer will have added the apple orchard, which has already about passed the experimental stage. With this important adjunct child-life and farm-life will be complete.

1. Describe the following trees, where are they found, and the character of their season of leafage, and their root system:—Oak, Poplar, Balm of Gilead, Ash, Elm, Ash-leaved Maple, Basswood, and Spruce.

2. Make a list of our native flowering shrubs.

3. Which is the more valuable, a maple from the open or one from a deep bluff. Why?

4. Why will a hollow tree live and a girdled tree die?

5. What is the value of tree pruning? Which branches are sacrificed?

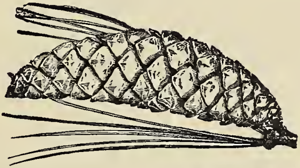
6. What causes the rings of a tree, and the grain of a board? Secure a cross-section of a tree and endeavor to read its history.

7. When are the following seeds ripe:—Elm, Maple, and Basswood? How does each tree plant its seeds?

8. Prepare a plan of your school grounds. Show on the plan what trees you would plant in order to make ideal grounds.

9. Make a study of the mutual relationship of the various tree species on a bluff.

10. Should belts of trees be grown from seed, or should these belts be composed of transplanted trees? Give reasons.



Cone of white pine. (One half natural size.)

CHAPTER XXXV.

ROADS.

"A good road is one that is good in bad weather."

Early Roads.—The Indians made their journeys by canoe-routes and by trails. The former followed the winding streams and lakes, shortened in places by portages or "carries." The latter wound in and out, up and down, following the easiest natural route. There was little or no attempt at making or improving the road or path. Large stones and fallen trees were avoided, not removed, and a good surface to the path was got only by long use, not by any attempt at direct improvement. The condition of the roads is a fair test of civilization—the savages do not make roads.

The first settlers of the West made use of the Indian trails already mentioned, and added others of a similar character. This continued until farmers began fencing their farms, thus shutting off portions of the "prairie trail," and compelling the opening of the "road allowances." These first "made roads" consisted of raising the prairie surface, with the earth thereon, out of the ditches on either side of the road bed. This second stage was a great improvement; the water drained off into the side ditches, and the roadway was kept fairly dry. The wheels of carts and the feet of horses and of oxen do not cut into the dry earth so easily as into the mud. Such a road as this we call a dirt or earth road. Many are still found,

and they are the only kind of road possible in certain places, but in order to be useful they must be kept well rounded up and well drained on the sides. The greatest enemy of all roads is water, whether it is water *in* the material of the road, or on the surface of the road. The frost can do no damage unless there is water in the road. You know that water expands when it freezes, so that when a wet road freezes it heaves, and becomes broken up. This, then, is the first principle of road-making—keep it dry by open drains on the side, or by covered tile drains on the side, or by tile drains below the road.

The next principle in road-making is to get a fairly hard surface. In the early days the settlers sometimes cut down small trees, and, after trimming them, laid them side by side across the dirt road. By this means there was made a surface that was hard but a little rough. Such a road, from its ribbed nature, was called a "corduroy" road. Later on, when saw-mills became common, sawn planks were sometimes laid down, forming a plank road. The object in both cases was to get a hard, level surface. A horse can pull but a light load through loose sand or deep miry mud; he can draw much more on a hard, level road; he can draw still more on a level steel track. Why is this so?

GRAVEL ROADS.—Another way to harden the surface is to put hard, stony material upon it. First of all, good gravel may be used, and a coating of it laid along the roadway. You will at once ask if loose gravel is not difficult to drive through. So it is. Therefore we must get the gravel well packed together, and so a roller is used. After first rolling the dirt roadway, a layer of gravel is put on, and the heavy roller is again driven back and forth, every time crushing the gravel down a little, and packing

it together a little more closely. This should be done scores of times if necessary. The number of times will, of course, depend upon the roller; a heavy 20-ton steam roller will not need to be passed over the gravel as often as a 6-ton roller drawn by two teams of horses. Unless the gravel is rolled in this way, it remains loose and soft when the fall rains come on; the wheels of waggons cut through it, and mix it with the mud beneath; and so the gravel is wasted and the road is not nearly so good as it should be. Then more gravel is put on and rolled again, and a nicely rounded or crowned surface is made which will shed the rain-water into the side ditches, and which is so hard and compact on the surface that the wheels will not cut through.

But big open ditches on the side are unsightly; they get choked up with weeds, and are frequently dangerous to horses and travellers. They should be kept clean, of course, so that the water will not stand in them. But the better plan is to put down a covered tile drain on each side of the road, and leave only a hollow ditch above it. The grass will grow over this, and a neat roadside will result.

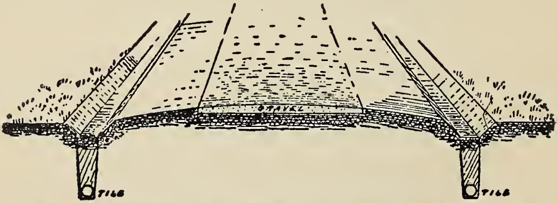


Fig. 70.—A gravel road properly crowned, with side ditches and tile drains.

In order to get a strong, tough surface, the gravel must be well packed together, that is, it must "bind." If we

mix together in the road coarse gravel and fine hard stony material and soft fine dirt, the road will soon become uneven. It is necessary, therefore, to have the gravel well screened; then the coarser part should be spread on the roadway and well rolled, and the finer gravel spread upon it to form the surface. All soft material, such as sods and loose dirt, should be kept out of the gravel ; in short, the gravel should be as clean as possible ; it should be screened, graded, and put on in layers, and should be well rolled.

STONE ROADS.—As a rule, gravel is more or less rounded, and therefore, does not at first bind well. You know that a road could not be well made out of marbles. To bind well there must be sharp corners and rough sides on the pieces. So we find that broken stone will make a stronger and more durable road than will gravel. But we must remember the points already referred to, namely, the road must first of all be thoroughly drained, both underneath and on the sides; the stone must be put down in courses, the largest below and the smallest on the surface, and every course must be thoroughly rolled as it is

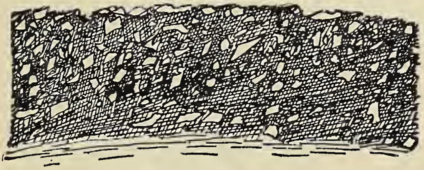


Fig. 71.—This is the kind of road that is made by placing loose stones on a dirt road without properly preparing the foundation—the stones sink through the mud beneath.

laid. It is a mistake to leave the rolling until the road is all filled in. The dirt subsoil should first be well rolled. In using broken stone care should be used in choosing a

tough rock ; if the rock is soft it will soon be ground into dust. Tough limestone and the hard rock called trap are the best. Sandstone and most kinds of granite are too easily crumbled for use on roads for heavy travel.

Now, as to the mode of building or laying a stone road. First of all, we may build the road of broken stones, none of which are over three inches in diameter, laying the stone in courses, and well packing it by rolling. In this way we make what is called a macadam road. It is so named after a Scottish engineer, John L. Macadam, who lived from 1756 to 1836, and who originated this method of making roads.

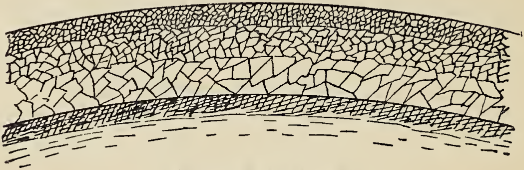


Fig. 72 —A Macadam road.

We may, however, begin the road by laying a foundation of flat stones from six to eight inches in thickness, then a layer of coarsely broken stone, another layer or course of more finely broken stone, and a thin coat of fine gravel or screenings on the surface—all well compacted by a heavy roller. This kind of road is called a Telford road, from the inventor, Thomas Telford, a Scottish engineer, who lived from 1757 to 1834.

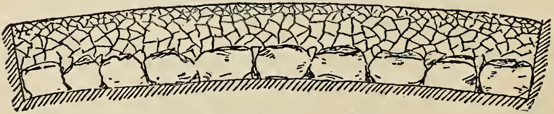


Fig. 73.—A Telford road.

The legal width of a country road allowance is 66 feet. The usual travel on such a road does not require more than 24 feet of this to be graded and crowned. In the centre of this graded portion the metalling (that is, the broken stone or gravel) is placed, having a width of 6 or 8 feet, and a depth of 9 to 12 inches, according to the number and weight of the vehicles which will pass over the road. As the country becomes more thickly populated, and the number of vehicles using the roads increases, it will be found necessary to make the metalled portion wider than 24 feet.

NOTES :—

Broad tires should be used on heavy waggons and carts, as wheels with wide tires will not sink so readily in sand and dirt as wheels with narrow tires—in fact, the wide-tired wheels have the same good effects as a roller on the surface of the road.

The greatest enemy to good roads is water in the road-bed and water on the surface. Notice how a small hole on the surface of a road becomes larger soon after a rain.

The best time to mend a road is just as soon as it needs mending. "A stitch in time saves nine."

The road surface should be nicely crowned, so as to shed the water to the side ditches ; the side ditches should be kept clean and uniform, so that the water will run away and not stand in them; the road sides should be level and sloping towards the ditches, and should be covered with sod, all weeds, stumps and shrubs being cut out.

The fences along the road should be kept neat and trim. If trees are planted along the roadside, they should be far enough apart to allow the sunlight to keep the road dry.

As a rule the roads are a sure index of the intelligence, enterprise, and prosperity of a farming community. Poor, cheap roads are a source of great expense to farmers. Good roads, well-kept, will enable the farmer to draw heavier loads in a shorter time, cause less wear and tear on vehicles, horses and harness, will add much to the pleasure and satisfaction of living in the country, and increase the value of farm property.

A good road brings a farmer nearer to his neighbors, nearer to market, nearer to school, and nearer to church.

CHAPTER XXXVI.

THE COUNTRY HOME.

A Fine Country Home.—In the older countries of Europe most families of even moderate wealth endeavor to have two homes or residences, a city or town house and a country house. The greater pleasure, the more lasting recollections, are usually associated with the latter. When we clearly understand the nature and the surroundings of the rural homes, the country seats, of England, Scotland and Ireland, we do not wonder at the preference. With increased wealth, in the future a similar condition of affairs may, perhaps, result in this country, but the building up of pleasant, attractive country homes in this land need not be put off until the day of increased wealth shall make such possible to a few. Far better will it be for this country if every farmer's home can be made attractive and comfortable. Many men of the towns and cities, wearied and perplexed with the driving cares and the never-ending anxieties of their busy life, look forward longingly to a time when they can return to the country, for a part of the year at least, to enjoy the quiet, the comfort, and the healthfulness of a country home, even though it may be a very humble home. The young people of to-day will ere long be making homes for themselves; in fact, even now they can do something towards making their homes more attractive, hence it is not out of place to make a brief study of what the ideal country home should be. Home life in the country, as in the town, is the most important factor in building up character. A nation's life is largely the combined home life of all the families that make up the nation.

THE HOUSE.—The house depends for its attractiveness not upon what it is made of—stone, brick, wood, logs—but upon its form, its situation and its surroundings. In deciding upon the outline of a house both plainness and too much variation and decoration should be avoided. It should, if possible, face towards the south, to see the first of spring and the last of autumn; it should be near enough to the road to bring passing vehicles and traffic within range, and yet not right on or against the road. If possible, from the front there should be a pleasant outlook or landscape. It should stand on rising ground, so that there will be perfect drainage away from it, and no possibility of any drainage towards it.

Having selected a good site, we begin with the house, and, of course, start with the cellar. This should extend under the *whole* house, otherwise some of the rooms may be damp at times. The cellar should be deep enough so that one can walk about in all parts of it erect; it should have a concrete floor, and a well-laid drain from it to keep it dry. Have windows on all sides, so that the whole cellar can be kept well aired. If it can be arranged, have a root-cellar apart from the house, say in one corner of the garden. All this means a little extra expense, but damp, musty cellars and decaying roots result in sickness, sometimes in death, and the cost of a good cellar will be money well invested.

The arrangement of the rooms in the house is a matter largely of choice. There should be a large kitchen, a pantry, a dining-room, and a parlor on the ground floor. There should be also a reading-room or library or study, in which will be found the best agricultural papers, and at least a small collection of the best agricultural books and reports. Two other things should be provided for, namely, one large bow window for house-plants and a grate for a log fire. The sleeping rooms may be on the second floor, and, in addition, there should be a store-room and a bath-room.

So much for the inside. On the outside there should be a wide verandah with comfortable chairs. This will be found to be the summer living room. It should run the length of at least one side of the house, and, if the style of the house allow and the outlook be favorable, it should run around on a second side. Both sides will be used in different kinds of weather. Around the supports of the verandah there can be twined a climbing plant, Virginia creeper or ivy or honeysuckle or clematis or climbing rose.

The Surroundings of the House.—Two great essentials to health are pure air and sunlight; therefore, have plenty of windows, and keep all trees far enough away so that the windows will not be darkened. You wish a fine outlook from your verandah, therefore do not plant trees to hide the view. You should, or may have, a few trees along the main road and on either side of the winding driveway from the entrance-gate, but keep the front well open, so as to let in the fresh air and the sunlight, and so as to allow you to see out and away over the country. In the rear have a clump of spruce, to act as a wind-break against the cold north and north-west winds. On the side you may have a neatly-trimmed hedge of cedar, and here and there you may have a native shrub, but between your house and the road have a sloping lawn of green grass, clear of weeds, and well-trimmed. If the lawn is large enough you might have one or two shapely maples, but do not crowd out the grass or obstruct the view. And the flowers? On the side rather than in front, but choice and taste will settle where they are to go. Perhaps you can make a simple plan or sketch of a home such as we have briefly outlined. You will find that you will have to alter it to suit the general situation and lay-out of your farm, but, keeping in mind these simple principles as a guide, you can, if you will, make in time an ideal country home, which is one of the greatest blessings of any country.

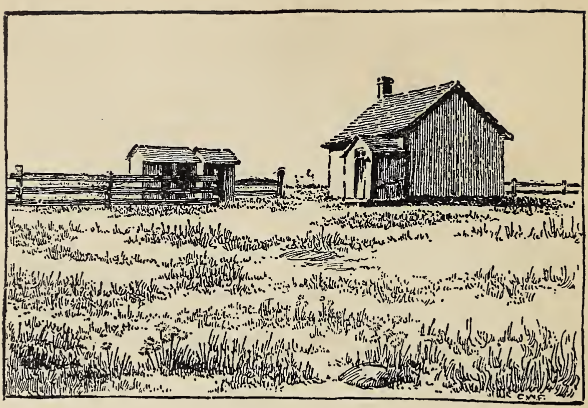


Fig. 74.—A country schoolhouse.

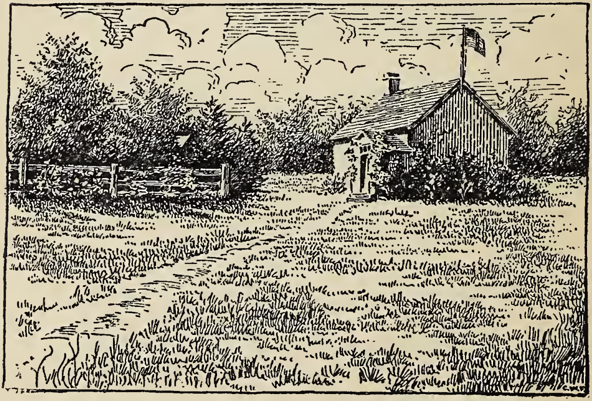


Fig. 75.— How it might be improved by adding some trees and shrubs (From Bulletin, College of Agriculture, Cornell University, entitled "Hints on the Planting of Shrubbery," Figs 21 and 22.)

The leading thought in planting home grounds, but particularly school grounds, is to have a setting of greensward for the central figure—the building—and then to frame this with an irregular border of trees, shrubs, and flowers, as shown in fig. 76.

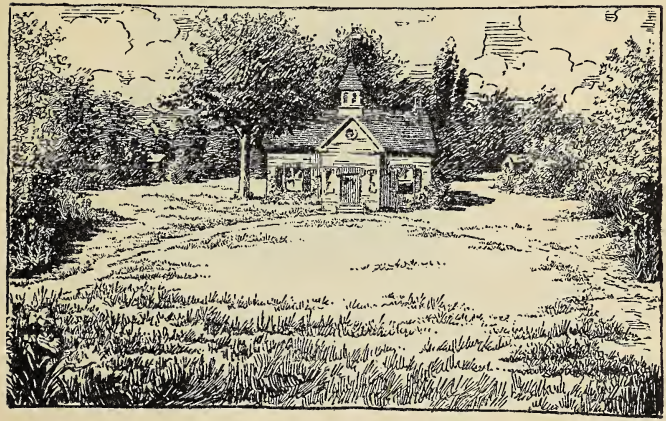


Fig. 76.—A picture, of which a schoolhouse is the central figure.

The border can always be added to or taken from without disturbing the arrangement. A hill of corn or a canna root may be inserted in the background with pleasing effect, while the foreground may be used for annual flowers.

Suggestions to the Teacher :

Are not the surroundings of the average country school bare and cheerless? (Fig. 74). May they not be improved by the planting of such native shrubs and flowers as might be picked up in a half-day's outing with the boys and girls? (Fig. 75). In this connection

the teacher will do well to consult "Hints on Rural School Grounds," Bulletin No. 160, Cornell University Experiment Station, from which the accompanying cuts are taken.

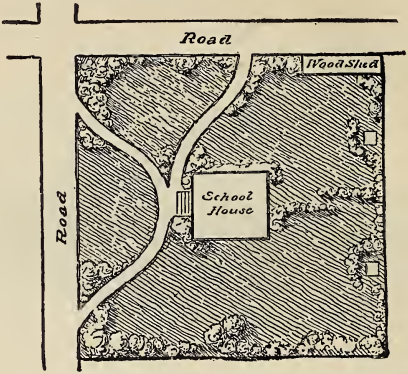


Fig. 77. A "corner" schoolhouse and how the grounds may be arranged

PART VII.

THE SCIENCE OF EVERY DAY LIFE.

CHAPTER XXXVII.

THE ATMOSPHERE.

1. The air surrounds us. We see its effects. We hear it. We feel it.

2. An empty bottle is really a bottle full of air.

Experiment (*a*).—Force a pickle bottle, or other suitable vessel, mouth downward, into a pail of water. When the bottle is three-fourths immersed, let it free. What have you experienced from this? What have you learned?

Experiment (*b*).—Take a funnel with a narrow stem. Fit it accurately in the neck of a small bottle by means of a rubber stopper. Pour water into the funnel. What is the result? How is it explained? Push a long, narrow glass tube, open at both ends, through the water of the funnel. Try to account for the result.

Experiment (*c*).—Transfer air from one bottle to another. From one room to another. On what principle can these be effected?

3. Air exerts pressure.

Experiment (*a*).—Fill a tumbler with water, and cover it with a piece of stiff paper (foolscap will do) of the same shape as the mouth of the tumbler, but a little larger. Hold the paper gently with the fingers of the left hand, and quickly invert the tumbler. Remove the fingers from the paper. Why does the water stay in the tumbler? Will it stay if the paper be removed? Give a reason for your answer.

Experiment (*b*).—Place a long narrow glass tube, open at both ends, vertically in a pail of water. Cover the outer end of the tube securely with the thumb of the right hand and lift the tube from the water. What has taken place? Compare experiments (*a*) and (*b*). Why was a narrow tube taken?

Experiment (*c*).—Cover the mouth of a glass funnel securely with a piece of sheet rubber. Apply the lips to the stem and suck out some of the contained air. In doing this hold the funnel in various positions. State what you have observed. Explain cause.

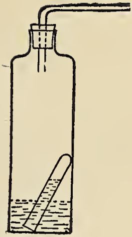
Why do we not feel this pressure?

4. Air has weight.

Procure a large glass flask, and fit into it a rubber stopper carrying a short glass tube to which a piece of rubber tubing is attached. Place a few ounces of water in the flask and boil the water. After boiling a short time close the rubber tube by means of a pinch cock and remove the flask at once. When the flask is cool, counterpoise it on a balance, or at the end of a wooden beam and open the pinch cock. What results followed? What is the inference? Why was water used?

The same results would follow if a flask similar to the above were used and the air sucked out.

5. Air is compressible.



Fill a small test tube half full of water and invert it within a wide-mouthed bottle containing a little water. Fit the neck of the bottle with a rubber cork and glass tube as in the figure. Apply the lips to the tube and—

(*a*). Suck out as much air as possible.

(*b*). Force air into the bottle.

Note the double result and give the explanation.

Apply what you have observed in the foregoing experiments to the following :—

(*a*). The drinking of lemonade with a straw.

(*b*). The lifting of water with the common pump.

(*c*). The working of a blacksmith's bellows.

(*d*). The reason for the efficacy of pneumatic tires, cushions, balls, etc.

(*e*). The explanation of the mercurial barometer, etc.

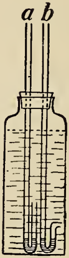
CHAPTER XXXVIII.

WATER.

1. Water presses upward, downward, and laterally on objects immersed in it.

Experiment (*a*).—Hold an empty baking-powder can, mouth upward, and push it slowly into water contained in a pail. Note your sensations while doing this. Describe them.

Experiment (*b*).—Make a small hole with a nail in the bottom of the can used in experiment (*a*), and repeat the experiment, only push the can to its greatest depth at once. What have you produced in the can? How high has this risen? What has caused it?



What have these experiments taught you regarding water? What difference in (*a*) would you expect were you to experiment in very salt water instead of in fresh water?

Experiment (*c*).—Lower two tubes of the shapes *a* and *b* into a pickle bottle filled with water. Put enough mercury into each tube to cover the bend entirely.

Note carefully the result in each case and give reasons.

2. Pressure increases as the depth.

Procure a deep tin can with vertical sides. Perforate the sides as follows: one inch from the bottom; four inches from this and above it; half way; and near the top. Fill the can with water and observe the character of the several streams. Make a diagram illustrating what you have observed. Which stream issued from the opening with the greatest velocity? Which with the least velocity? Can you account for this? Which stream struck the ground farthest from the bottom of the can? Can you see any reason for this? In throwing a dam across a stream what use would you make of this experiment?

3. The buoyancy of water.

Experiment (*a*).—Weigh a stone in the air; weigh it subsequently in water. Compare the two weighings. Can you account for the difference?

Experiment (*b*).—Place a tumbler three-fourths full of water in the scale-pan and counterpoise with sand or shot. Suspend the stone of (*a*) in this water until the stone is just immersed. See that you do not permit it to touch the sides or bottom of the tumbler. Counterpoise again with weights, and make a note of the extra counterpoise. Compare it with (*a*) above. Can you now see any reason for the supposed loss of weight of the stone?

Devise an experiment to prove that a floating body displaces its own weight of water. What use is made of the principle of buoyancy in swimming?

Can you see a reason why an iron ship will float?

Can you see a reason why it will float better in sea water than in fresh water?

4. Water seeks to maintain its level.

This principle finds illustration in the following instances: the flowing of streams; the water system of a town

where the source of supply is at a height; the behavior of artesian wells; the water-gauge in boilers and water tanks; the water-level, etc.

THE STUDY OF FILTRATION, SOLUTION, EVAPORATION, BOILING, AND DISTILLATION.

FILTRATION.

Experiment (*a*).—To a quantity of rain-water add some sawdust, clay, or sand, and stir well. Devise several methods of removing the added material. Examine the value and principle of each method.

Experiment (*b*).—To another small quantity of rain-water add some common salt, and stir. Try to remove this by any of the methods devised in (*a*). What reason can you give for any want of success? What is the difference between the two kinds of matter used?

SOLUTION.

Experiment (*a*).—To a half-cup of soft water add a spoonful of common salt. Set the cup to one side and note the time the salt takes to liquefy. Is *melt* a good term to use here?

Experiment (*b*).—Repeat the first experiment, but stir the salt thoroughly. How has this helped? Why? Is any use made of this principle at home? In what connection?

Experiment (*c*).—Repeat experiment (*b*), but grind the salt before adding it. Has the grinding helped? Why has it helped? Why is it a good thing to chew the food thoroughly?

Experiment (*d*).—Repeat experiment (*c*), but heat the the water as well. Has this improved matters at all?

Tabulate the results of these experiments, giving reasons for differences.

Make a list of substances soluble in water, and another of substances insoluble in water. Take starch, flour, camphor, bluestone, lard, or any fat, marble, sulphur and other common substances.

Why is soap used for washing purposes? Why is hot water used?

Does the nearest river or stream employ solution and suspension to move the material carried? Can you have a solution of two liquids? Of a liquid and a gas? Prepare and obtain such solutions.

EVAPORATION.

1. The rate of evaporation.

Experiment (*a*).—Place a few drops of alcohol and a few drops of water on the same glass plate. Note the time taken by each to disappear. Where have both gone? What evidence have you of this?

Experiment (*b*).—Repeat experiment (*a*), but place the liquids on a warmed glass plate. Is there a difference? What has produced it? What other instances have you seen of this?

Experiment (*c*).—Procure two vessels of about the same volume, but one wide and the other deep. Put the same quantity of water in each and set them side by side. In which has the water disappeared first? Is the reason found in the shape of the vessels? What other instances can you offer of a similar kind? According to this experiment, when does evaporation take place?

Experiment (*d*).—Dip two pieces of the same cloth in water. Wring out as much water as possible. Place one piece quietly on the table. Wave the other back and

forth vigorously for some time. Compare the two as to dryness. Illustrate other similar results.

Tabulate the results of the above experiments, and state the several conditions favorable to rapid evaporation.

2. Coolness results from evaporation.

Sprinkle a few drops of alcohol or ether on the hands. Describe the results. What has become of the liquid?

Bathe the hands in water, dry them by waving them in the air. Are the results in this case similar?

Mention various uses made in every-day life of evaporation.

BOILING.

Experiment (*a*).—Fill a glass flask about half full of water and apply heat. Note the following effects: rise of temperature; formation of bubbles (what are these first bubbles?); the formation and collapse of the first steam bubbles; simmering; the rising of the steam bubbles to the surface; the freedom of the steam; the agitation of the surface; the resulting temperature, etc.

How does this differ from evaporation? Find a term that would represent both processes.

Experiment (*b*).—Throw a couple of tablespoonfuls of common salt into the boiling water of (*a*). Note the effect of this. Take the temperature of the water when boiling again commences. Is it higher or lower than before? Why should the salt make this difference? Why does the cook sometimes put salt into a pot that is cooking meats or vegetables?

Experiment (*c*).—Boil some water in a small but strong glass flask. Continue the boiling for a minute or so, then cork the flask tightly and at once remove the source of

heat. Invert the flask in a ring of the stand, and as soon as boiling has ceased place a cloth saturated with cold water on the bottom of the flask. Pour cold water on this cloth. What result followed the application of cold water? Can you see any reason why this result should follow? Is the water in the flask hotter or colder than it was when the heat was removed? What substance should be in the space above the water? What effect has the cold water on this?

Infer from this experiment the relation the atmosphere bears to the boiling point of water.

DISTILLATION.

Fit a flask with a rubber stopper bearing a long delivery tube. Allow the free end of this tube to enter well another flask kept cool in a basin of water. Place some dirty water, in which salt has been dissolved, in the first flask and apply heat. Place a wet cloth on the second flask, and keep this well moistened with cold water. Collect an ounce or two of water in this receiver.

Taste this water. Examine its color. Try some with a little soap. Place some more in a clean evaporating dish and evaporate to dryness. What have you found in all these? Describe the process.

Show the value of distillation and condensation in everyday life.

How does distillation differ from boiling? Which do you think is the better to drink, distilled water or ordinary well-water?

COHESION AND ADHESION.

Experiment (*a*).—Cut a lead bullet in two. Press the parts together tightly. What is the result? Separate them by pulling. Is much force necessary?

Experiment (*b*).—Take two plates of ground glass. Place one on top of the other. Attempt to raise both by lifting the upper one only. Try two pieces of window-glass in the same way. How do you account for the difference?

Experiment (*c*).—Pour a little water on a greased surface. How does the water behave? Pour an equal amount of water on an ungreased surface. Compare the two results. With a greased rod push a couple of the drops so that they touch each other. What has happened to the two drops? Do they show any attachment for each other? What do you call this attachment, or better, force?

Experiment (*d*).— Take a piece of wood about four inches square and an inch thick. Set it down carefully on the surface of a basin of water. Pour in water until the basin is filled to the brim. Hold the eye on a level with the surface of the water, and slowly lift the block, lifting it at right angles to the water surface. Represent what you have discovered. Does the pull seem greater than the weight of the block? Why? Examine the under surface of the block after you have detached it from the water. Did you pull the wood away from the water, or did you break the cohesion of the water column? What causes the water to stick to the wood?

Experiment (*e*).—Take a glass vessel with straight sides. Fill it full of water. Pour out the water slowly. What happens? What has caused this to happen? Devise two or three remedies.

From the results of the foregoing define *cohesion*. What would be the consequences were the forces of cohesion and adhesion respectively to cease? Mention in this connection several instances from every-day life.

CHAPTER XXXIX.

HEAT.

1. Sources of heat.

Experiment (*a*).—Hammer a piece of lead on a stone or on a flat iron. Observe the change in temperature.

Experiment (*b*).—Rub a brass button briskly on a piece of cloth. What have you discovered?

The result of these experiments will help you to infer the relation of motion to heat.

Mention three other sources of heat.

2. Hot and cold.

Place three basins before you on the table. Pour water as hot as you can bear in the basin to the left. Pour cold water in the basin to the right. Fill the centre basin with lukewarm water. Dip the right hand into the cold water and the left hand into the hot water, and keep them there for a space of thirty seconds. Remove them, and immediately plunge them into the lukewarm water. Describe the sensations. Is the hand a reliable instrument in cases of temperature? Mention other instances showing that *hot* and *cold* are relative terms.

3. Effects of heat.

A. Change of volume or size.

Experiment (*a*).— Take an iron rod about eighteen inches in length. Support the ends of the rod on a couple

of bricks. Fix one of the ends by letting it rest against a support. Allow the other end to rest on a glass tube, to one end of which attach a toothpick by means of sealing-wax. Heat the free portion of the rod by means of a couple of spirit lamps, and note the behavior of the pointer. What is the cause of this? Test a copper rod in a similar manner.

Mention other cases where a like result took place.

Experiment (*b*).—Fit a flask with a rubber cork carrying a straight tube of glass six or eight inches free. Fill the flask and a couple of inches of the tube with water. See that no air remains under the cork. Place an elastic band about the glass tube marking the height of the water. Apply heat, and note the effects. What is the inference?

Mention other instances of a similar character.

Experiment (*c*).—Arrange a flask as in experiment (*b*). See that it is perfectly dry. Hold the flask and tube in a vertical position, the end of the tube dipping into the water of a beaker. Apply heat to the flask, allowing the flame to sway to and fro so as not to break the glass. What is the effect of this? Remove the heat and let the flask cool, but keep the latter still in the water. Account for the second result.

Tabulate the results of (*a*), (*b*), and (*c*), and infer the general truth.

Apply the general truth in several common experiences.

Explain the common thermometer as far as you can. Make and grade an air thermometer. Point out where the instrument is superior to the school thermometer.

B. Change of temperature.

Refer to experiments under 3, above.

C. Change of state.

Experiment (*a*).—Place some chips of ice in an evaporating dish, and apply heat until the water formed has been turned to steam.

Experiment (*b*).—Place some paraffin-wax in the same dish, and heat for a time.

Experiment (*c*).—Put some lead in a common tablespoon, and heat.

What has happened in all these cases? Are the wood and coal that are consumed in the stove examples of a similar change? Can the change be reversed? How?

4. Temperature and quantity of heat.

From a beaker of hot water take a tablespoonful of water. In what respect does the water in the spoon agree with the water left in the beaker?

Pour equal quantities of cold water into two separate beakers, and add the spoonful of hot water to one and the hot water in the beaker to the other. Compare the resulting temperatures. In what respect did the water in the beaker differ from the water in the spoon?

5. Comparative heating effects of lead and water—or of iron nails and water.

Place equal weights of lead shots and water in two test tubes standing in the same beaker of water. Heat the water in the beaker to the boiling point. Have at hand two beakers containing equal weights of water at the temperature of the room. Carefully pour the hot lead into one beaker and the hot water into the other. Stir, and take the resulting temperature. What do you infer from this?

Can you see any reason why the winter should be slow in reaching, and also slow in leaving an island region?

Can you also see a reason why a district bordering on

a large body of water should not be subject to sudden changes?

6. A comparison of the cooling effects of melting ice and water.

Experiment (*a*).—Take equal weights of hot water in two beakers. Add a handful of ice chips to the water of one beaker and stir. When the ice has melted note the temperature. See that the water in the second beaker is restored to its original temperature. Pour cold water into this beaker, until the same temperature has been reached. Find how much ice and ice-cold water you have added. What does the difference mean?

Experiment (*b*).—Take a pound of ice chips just melting, and place them in a beaker containing a pound of water at a temperature of 80 degrees Centigrade. When the ice has all melted and the temperature of the resulting liquid has become fixed, take this temperature, and use it to explain how much heat a pound of melting ice must get before it will all change to water.

Explain:—The slow formation of ice in ponds and streams, and the slow melting of the same; the feeble effects of a March sun compared with those of a September sun; the efficacy of placing tubs full of water in cellars containing vegetables.

TRANSMISSION OF HEAT.

CONDUCTION.

Experiment (*a*).—Obtain rods of iron, copper, lead, and glass. Let the diameters be as nearly the same as possible, and the lengths from five to six inches. Place the rods on a brick, so that they spread out like the spokes of a wheel. Apply heat where the rods converge, and pass

the fingers slowly along each rod, from the ends remote from the flame. Compare the extension of the heat in each case. Do all the rods behave equally in each particular? Which is poorest? Which best?

How do you suppose the heat is able to work back some distance from the source of supply? Classify the following substances as good conductors and bad conductors:—wood, brass, iron, glass, feathers, woollens, paper, etc. Mention a variety of uses made every day of bad conductors.

Experiment (*b*).—Fill a long test-tube nearly full of cold water. Apply the flame of a spirit-lamp near the surface of the water. Notice the effect. Prove that the water at the top is much warmer than the water at the bottom. If the heat could get down to the bottom how would it do so? Would you classify water as a good conductor, or as a poor conductor? Why are houses sometimes built with hollow walls? Why are double windows used in winter-time? Do you consider air a good or a bad conductor?

CONVECTION.

Experiment (*a*).—Heat over a small flame a round-bottomed flask (why this shape?) nearly full of water. Place in the water some solid coloring matter, like litmus-cubes. Notice the movements of the water during the process of heating. Explain the currents observed.

Experiment (*b*).—Arrange apparatus as in the accompanying figure. Fill the system with water, and place a spoonful of

ink in the upper vessel. Apply heat to the lower vessel and note the movement of the water.

The upper flask may be readily made by knocking off the end of a pickle bottle.

Explain how houses are heated by hot water.

Why are cooking vessels heated at the bottom and not at the top?

Experiment (*c*).—Place a short piece of candle in a saucer. Light it and place over it a lamp chimney; pour sufficient water in the saucer to seal the bottom of the chimney. Observe the behavior of the candle. Now, cut a strip of cardboard a little less than half the length of the chimney, and as wide as the upper internal diameter. Place this in the chimney and rekindle the candle. How does the candle behave with this modification? Burn some brown paper near the top of the chimney. Does this give you a reason? If a candle placed as in the first part of the experiment continues to burn under such circumstances, what must have taken place? Will this take place more readily in a large chimney than in a small one? Mention other instances of the convection of gases. Can you give any reason why a chimney built in a north or a west wall may occasionally smoke during the winter?

RADIATION.

Heat a piece of iron in the stove until it is nearly red hot. Remove it and suspend it by means of a wire. Hold the palm of the hand a short distance beneath the ball. Is this a case of conduction? Is it a case of convection? Give reasons for answers given. Hold a thin board between the hand and the ball. What effect has the board on the heat? Give other instances of radiation.

Why is ice packed in sawdust?

What is the purpose of the tea-cosy?

Why does tea remain hot longer in a polished tea-pot than in an earthenware pot?

Why are broad-rimmed hats worn in the summer time?

How is the temperature of the air affected by latitude; the season of the year; the hour of the day; the position of the place, with respect to land and water; and the altitude of the place?

CHAPTER XL.

SIMPLE ANALYSIS OF THE AIR.

1. The water in the air.

Place a few lumps of dry calcium chloride in a saucer. Weigh saucer and contents, and expose to the air for a few hours. What has occurred? Weigh again. What has happened? Where did this come from? What evidence have you that the air contains water? What is the value of this water?

2. The air contains carbon dioxide.

Experiment (*a*).—Pass the breath through a little good lime water in a test tube. Make a note of the result. This always happens when the gas carbon dioxide is passed through lime-water, and the breath contains a little of this gas.

Experiment (*b*).—Arrange apparatus so that the out-door air may be drawn through another sample of lime-water. In the course of a few minutes the same result is observed. What is the inference? Which do you think is the richer in this gas—air or the human breath? What is the value of the carbon dioxide of the air?

Experiment (*c*). Fill a large bottle with water and invert it in a basin of water. Fill the lungs with air; retain it for a time and then pass it slowly, by means of a tube, into the bottle. Procure any active water plants and place them in this bottle. Put the basin and bottle in

the sunlight for a day or two. What effect has the change had on the plants? Has any water entered the bottle? Remove the jar and quickly invert it, and plunge a lighted candle into it. How does the candle behave? Fill another jar with air expelled from the lungs as before, and try the experiment with the lighted candle again. What is the result this time? Can you account for the difference? Can you answer the last question under experiment (*b*), above?

3. The dust in the air.

Clean an evaporating dish thoroughly. Collect some of the rain falling at the commencement of a smart shower. Evaporate the water and examine for any solid matter. Where did this come from? How did it get there? What is it doing?

4. The two chief gases of the air.

Experiment (*a*).—Boil a little water for a few minutes. Set the boiled water aside, and drop into it a bright steel pen. Cork the bottle.

Experiment (*b*).—Take some of the same water (unboiled) and do the same thing with another pen. In a couple of days examine the pens. Can you give any reason for the difference?

Experiment (*c*).—Carefully weigh a small evaporating dish containing some clean iron filings. Moisten the filings, and allow the whole to stand for a day or two. At the end of this time, dry the filings and weigh the whole again? What has caused the increase of weight?

Experiment (*d*).—Place some moistened iron filings in a muslin bag. Tie the bag to the end of a glass rod, and place above the water in a pickle bottle, inverted in a vessel of water. Examine in the course of a few days. What change has taken place in the water? What

change in the filings? Explain why the water has risen. Connect this with (*c*), above.

Experiment (*e*).—Place a small piece of phosphorus, about the size of the head of a pin, on a brick, and touch with a hot wire. Describe the results.

Experiment (*f*).—Place another piece of phosphorus, about the size of half a pea, upon a piece of cork floating on water in a plate. Dry the phosphorus by touching it with the corner of some blotting paper. Ignite the phosphorus as in the former case, and cover with a beaker.

How does this experiment differ from experiment (*e*)? What became of the white smoke in each case? Prove by using a piece of blue litmus paper that the water in the plate contains an added substance. Can you account for this change? What portion of the original air remains in the beaker? What portion has been changed? Where is it now? Has it been changed to a solid, a liquid, or another gas? Show the effect of the remaining gas on a lighted splinter. What is the name of this gas? At present can you conceive its value?

Caution.—Never touch phosphorus with the fingers; always lift it by means of a pair of tongs. *Throw the cork used* in the experiment into the stove *as it still* may contain particles of *phosphorus.*

5. Study of the active constituent of the air. When should we look for this? Why?

Experiment (*a*).—Place a few crystals of chlorate of potassium in a dry test tube and heat it. Observe three effects.

Insert a glowing splinter. What happens? Compare this with the experiment with the phosphorus. This gas is *Oxygen.*

Experiment (*b*).—Mix the chlorate with a little man-

ganese dioxide. Repeat experiment (*a*), and note any differences.

Experiment (*c*).—Take larger quantities of the substance used in (*b*). Place them in a test tube carrying a rubber stopper, and a long delivery tube. Fill several small pickle bottles and insert in a basin of water. Heat the generator gradually and collect the gas. If the supply of material in the generator becomes exhausted, replenish, and continue until the bottles are filled.

What is the color of the gas at first? What is its color after a time? What is the cause of this? Is the gas soluble in water? Is it heavier or lighter than air? Will the gas burn? Will it support combustion? How would you distinguish it from air? Burn sulphur, charcoal, and a thin iron wire in separate jars.

NOTE.—Scoop a small hole in the large end of a crayon of chalk. Wind wire about the crayon. This will answer the purpose of a spoon. In the hollow, place a small lump of roll sulphur. Ignite it in the air, and then lower it slowly into the receiver. It is well to cover the bottom of each receiver with a little water. Why? In the case of the charcoal, wind a piece of wire about the coal. Heat it to glowing in the air, and then introduce it into a second receiver. Draw the temper out of a small watch spring by heating it red hot in a flame. Tip the end by dipping it in a little melted sulphur. Light the sulphur end and lower into a third bottle.

Can you now see the value of so much *Nitrogen* in the air?

Write out this experiment in full, making careful diagrams illustrative of the main facts.

CHAPTER XLI.

THE COMBUSTION OF WOOD AND COAL.

Experiment (*a*).—Fit a long test-tube with a rubber stopper having a tube of glass a couple of inches in length. In the test-tube place a few bits of wood, or a few pine shavings. Heat the shavings strongly, and make a note of what happens. In the course of a minute or so bring a light to the end of the jet. Hold a piece of cold iron a short time in this burning gas and examine the iron. What is the moisture in the iron? Where did it come from? Where did the inflammable gas come from? Continue the heating of the shavings until gases cease to be given off. Examine the charred substance left. What is it? Place a bit of it in water; how does it act? Heat another portion in the air, on a piece of tin; what is the residue? Mix the residue with a drop or two of water and dip into the mass a corner of a piece of red litmus. What does this mean?

Compare this statement with the experiment on the distillation of water.

Tabulate the constituents of wood as revealed by this analysis.

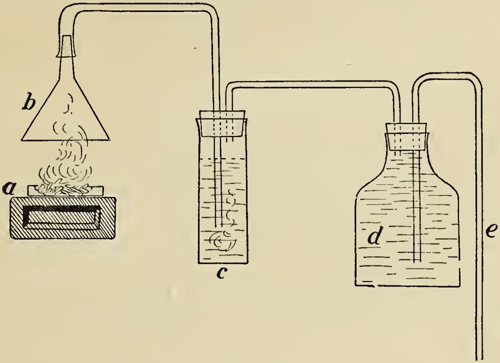
Make a comparison between the burning of wood or coal in a stove, and the burning of the shavings above.

Why are draughts necessary on a stove?

What causes the white smoke to arise from chimneys on frosty mornings?

Why is this not so much in evidence as the day advances?

Experiment (*b*).—Arrange apparatus as in the following diagram: *d* is a large bottle or can carrying a syphon-tube *e*, and connected with the bottle *c*, which contains lime-water. In the cover of a baking-powder can *a*, placed



on a brick, put some dry shavings. *b* is a large tin or glass funnel connected with *c*. Fill the bottle *d* with water, light the shavings, and start the syphon *e*. Note the change in *c*. What does the change signify? When was the gas formed? How? Show that the food taken in by the body undergoes a somewhat similar change.

THE BURNING OF A CANDLE.

Experiment (*a*).—Light a candle, and hold mouth downward over the flame a cold, dry tumbler. What collects

on the inside of the tumbler? Where did this come from? What previous experiment does this resemble?

Experiment (*b*).—Lower a lighted candle into a wide-mouthed bottle by means of a wire. Cover the mouth of the bottle loosely with a wooden cork. What happens? Remove the first candle and quickly put in another. What happens? Add a little lime-water and shake it up in the bottle. Pour the lime-water out into a clean test-tube and note the change in color. What has taken place? People sometimes lower a lighted candle into an old well before descending; can you see any reason for this?

Experiment (*c*).—Stick a small candle to a saucer. Add enough water to fill half the saucer. Light the candle and invert over it a pickle bottle. Pour water immediately into the saucer, and continue to do so until the candle is extinguished. Compare this experiment and the experiment with the pea of phosphorus. Point out all the resemblances and differences. Show the bearing of this on the question of ventilation.

Experiment (*d*).—Substitute a lighted candle for the shavings in experiment (*b*), of preceding topic. Compare results.

STUDY OF THE CANDLE FLAME.

Experiment (*a*).—Light a candle, and place behind the flame a piece of white paper to serve as a background. Endeavor now to make out the various flame-zones or mantles of the flame. Describe the colors and positions of each. Make a diagram showing the zones.

Experiment (*b*).—Spread out the top of the wick and light the candle. Quickly plunge the head of a match into the centre of the flame, bringing it to rest close to the top of the wick and at the centre. Hold it in this position for

a few seconds and make a note of the result. Remove it and make an examination of it. What does this experiment teach you is the nature of the central zone of the candle flame?

Experiment (*c*).—Draw a glass tube about two inches long to a jet. (To do this take a piece of tubing four inches long. Hold it in the tip of the flame of a spirit lamp so that the centre of the tube is heated. While heating keep the tube rotating. When the glass becomes quite soft remove and pull evenly.) Place the wide end of the jet-tube about where the head of the match of experiment (*b*) rested. Hold the tube obliquely by means of a bit of wire, and try to light what issues from the jet end of this miniature chimney. Do you see now why the match head did not ignite? Why does this gas not burn in the central zone? Can you devise a scheme by which it will burn?

Experiment (*d*).—Place a cross on the paper used as a background. Look through the dark zone of the candle flame and state whether you can see the cross plainly or not. What does this tell you of the character of this zone? Why did you call it dark in color?

Experiment (*e*).—Place a chalk-crayon across the candle flame at its centre. Remove in a short time and examine. Where did this deposit come from? What is it? Does it ever get out of a flame? In what zone was this deposit made? What is the value of this to the flame?

Experiment (*f*).—Hold a dry splinter of wood as you held the chalk. Remove when you see it has taken fire. Where is the flame hottest? Why do you think so? Where coolest? What becomes of the carbon dust of the white zone? Do you know why this zone is white? Is it more serviceable because it is white?

Experiment (*g*).—Light the spirit lamp. Is this flame a good one to read by? Why?

Take two pieces of wood charcoal. Hold them over the lamp flame and rub them together. Allow the dust to drop through the lamp flame and note the effect. Can you now explain the value of the carbon dust in the white zone of the candle flame?

Experiment (*h*).—Make a large flame on the candle. Have a lighted splinter at hand. Blow out the candle and re-light it at once by bringing the splinter near the wick. You may have to try this a few times before succeeding.

Why does blowing extinguish the candle flame? How were you able to re-light it without touching the wick? Does blowing always put a fire out? Explain.

THE CONSTITUTION OF A CANDLE.

What is the situation of the candle wick? Why is it so placed?

What material is it made of? Would any other material do? Would a fine rod of wood do? Would a knitting needle do? Give reasons. What would be the effect of increasing the diameter of a candle, the wick remaining the same size?

What is the source of the wax? Name other substances that would answer the purpose. What becomes of the wax? What changes are necessary before the candle flame is formed? What is a flame?

Compare the burning of a lamp flame and the burning of a candle flame.

Why is a chimney required for a lamp?

LIMESTONE, QUICKLIME, SLAKED LIME, LIME WATER, AND MORTAR.

LIMESTONE.

Examine a specimen. Note its hardness, color, weight. To what extent is it used for building purposes in the district? Are there any lime-kilns near?

A lime-kiln is a special furnace for heating limestone and carrying away the gases forced out of the stone. Large quantities of carbon dioxide gas are eliminated, thus showing that this gas enters prominently into the constitution of the stone. The residue of the stone drops to the bottom of the kiln, and is removed and sold as quicklime.

QUICKLIME AND SLAKED LIME.

Procure a good specimen of this. Note the care taken of it by the dealer.

Place a few lumps of quicklime in a deep plate and add water until no more is absorbed. Note the behavior of the quicklime. What causes the steam to issue from it? Is it growing hot? Can you account for this? When action is over in what condition is it? Is it dry? Does it weigh more than before? Does it take up more space? Can you explain any of these? Is the powder the same thing as the quicklime? Can you now explain why so much care must be taken of quicklime? A farmer starts from town with a load of quicklime. On the way home he is overtaken by a heavy rain. What effect might this have on the quicklime?

LIME WATER.

Take some of the slaked lime made in the last experiment, and shake it thoroughly in a bottle half-full of rain

water. Allow it to stand until it is clear. Pour off the clear liquid into a clean bottle. Taste it. Add a piece of red litmus. Boil a sample in a test tube until it is dry. Force the breath through another sample for a time. Find out what makes the lime water milky.

Tabulate these results and try to explain them.

MORTAR.

Take another sample of the slaked lime. Add a little water and sand. Mix. What do you call this? Place this between two bricks and examine it from day to day. Why does it harden?

CHAPTER XLII.

THE STUDY OF THE GAS CARBON DIOXIDE.

1. Carbon is the basis of all organic substances.

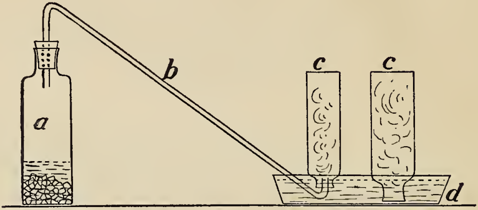
Experiment (*a*).—Heat small quantities of meal, potato, grains of wheat, sugar, cotton, etc., in clean, dry test-tubes, as you did the shavings in a previous experiment. What substance remains? Where do animals and plants get this carbon (charcoal)? How does the gas named get into the air? Mention several sources.

Experiment (*b*).—Pass the breath for some time through some rain water contained in a large tumbler. Pour a little of this water into a test-tube containing lime water. Can you now tell the purpose of the experiment?

Take a fresh bunch of any water plants: anchor them at the bottom of the water in the beaker, and cover with a glass funnel. Invert over the funnel a test-tube full of water, and set the whole in the sunlight for a few hours. Describe what takes place. Remove the test-tube by closing the mouth with the thumb. Have a lighted splinter ready, and dip this into the gas of the test-tube. What follows? Can you name the gas? Where did it come from? What had the light to do with this? Devise an experiment to prove your answer. Show how animals and plants unite in keeping up the balance of nature.

2. The preparation of carbon-dioxide gas.

Experiment (*a*).—Arrange apparatus as in the following diagram :—



Into the bottle *a*, which is fitted with a rubber stopper, carrying the delivery tube *b*, place several lumps of marble; cover the marble well with dilute hydrochloric acid, and collect the gas in the receivers *c c* inverted over the water in the basin *d*. After filling several bottles, pass the balance of the gas through lime water contained in a small bottle.

Experiment (*b*).—Invert the first jar and lower into it a small lighted candle. What happens? How does this gas differ from the gas, nitrogen, in this particular?

Experiment (*c*).—Pour the contents of a second jar on a candle flame. What other property of the gas is shown in this?

Experiment (*d*).—What observations have you made regarding the lime water of experiment (*a*)? Can you explain any of these phenomena? Divide this lime water into three portions. Boil the first portion after connecting the vessel with a small quantity of pure lime water. What are the results? Can you infer a reason for these? Add fresh lime water to the second sample. What has

taken place? If nothing but carbon dioxide can produce the milkiness, how do you account for it here?

Try to make a lather of the remaining portion of the lime water by using a little soap or soap solution. What is the nature of the water? Give one source of hardness in water.

Test the well-water for hardness. Is it hard? Evaporate a sample of it. Is any deposit left? Add a few drops of hydrochloric acid to this. Does it act as in the case of the marble? If so, what is present?

Examine the tea-kettle at home. Is it "furred"? Where did this come from? Procure a piece of this sediment and test it as you did the marble. Connect the generator with a bottle of lime water. What is the result?

Do you consider hard water to be good drinking water? Give your reasons.

CHAPTER XLIII.

THE COMPOSITION OF WATER.

1. The effect of the metal, sodium, on water.

Experiment (*a*).—Cut off a piece of sodium the size of a small pea and place it upon the water in a plate. (Do not touch the sodium with the fingers.) Observe the behavior of the sodium. How does it resemble the action of a drop of water on a hot stove?

Experiment (*b*).—Bring a lighted splinter near the floating sodium. Hold the face away from the plate for safety. What happens? What is burning? Why did it not burn before?

Experiment (*c*).—Fill a test tube with water and invert it in the plate. Make a small wire gauze cap and place a bit of sodium in it. Set the cap under the mouth of the tube and note what happens. Where do you suppose this gas came from? Was this gas formed in experiment (*a*)?

Lift the tube from the water without inverting it. Bring a flame to the mouth of the tube. Describe the result. What was the purpose of the flame? What made the explosion? The gas that was formed by the sodium is called *Hydrogen*.

Make a short summary of what you have already learned regarding hydrogen.

Experiment (*d*).—Examine the water in the plate—taste it—rub it in the fingers. Put a piece of red litmus paper in it. Evaporate a portion of it to dryness. Describe the substance left. How do you account for its presence? What has become of the sodium?

2. The study of the gas, hydrogen.

Experiment (*a*).—Fit up apparatus as in the case of carbon dioxide. Have an extra rubber stopper carrying a glass jet, a few inches in length, ready. Put several clippings of zinc into the generator. Cover this an inch deep with water, and add sulphuric acid slowly, pouring the acid down a glass rod. When action has commenced well, insert the cork and delivery tube. Allow the gas to escape into the air for a couple of minutes. Then collect several bottles of it. (Small pickle bottles will answer the purpose as well as larger ones). Make a note of all the phenomena connected with the generation of the gas.

Experiment (*b*).—After filling the last bottle, substitute the glass jet for the delivery tube, and light the jet. (If either the zinc or the acid should become exhausted, renew.)

Caution.—Do not allow any of the acid to get on the clothing or fingers. Should any acid get on the clothing moisten the spot with some ammonia. Should the acid get on the hands bathe them in fresh water. Never light hydrogen gas until you are satisfied that no air is present in the generator. See that no flame is used

What is the color of the hydrogen flame as it issues from the glass jet? Satisfy yourself that it is a hot flame. Is it luminous? How would you render it luminous?

Experiment (*c*).—Bring over the hydrogen flame a cool tumbler. What did you find gathering on the inside of the tumbler? Where does this come from? Collect a

few drops of this liquid and satisfy yourself that it is water by dropping a bit of sodium as large as a pin's head in it. What other gas must be combining with the hydrogen? Give your reasons for thinking so.

Experiment (*d*).—Take two bottles from the basin. Hold one bottle mouth upward and the other mouth downward for a few minutes. Then, without changing the position of the bottles light the gas in each. What have you found? Can you see any reason why hydrogen is sometimes used in balloons?

Experiment (*e*).—Light a long splinter of wood. Raise the third bottle of the gas, holding it so as to retain the gas. Bring the lighted splinter to its mouth and pass it into the bottle. What takes place? Bring the splinter out again. What has happened? Do this several times. Would you consider hydrogen a supporter of combustion. How does it resemble nitrogen and carbon dioxide? How differ from them?

CHAPTER XLIV.

THE STUDY OF SULPHUR.

Take a piece of roll sulphur and note its properties What is its color? Break off a small piece. What property is shown here? Find if it is soluble in water. Place a small piece on the lid of a can and heat it. What happens? Describe the smell of the resulting gas. Is it *Sulphur*? What has the sulphur combined with? Review what you have learned under "Oxygen" in this connection. Hold a delicately colored flower in the fumes of sulphur. What change has taken place?

APPARATUS AND CHEMICALS.

In order to perform satisfactorily the experiments in Part VII, the following apparatus and chemicals are necessary:

APPARATUS.

2 pickle bottles, large.
2 “ small.
2 Florence flasks, 4 ozs.
2 “ 8 “
2 medium sized beakers.
6 test tubes, 3x⅜ in.
6 “ 5x½ “
6 “ 6x⅝ “
2 common tumblers.
1 lb. lead shot.
1 chemical thermometer, for ascertaining temperature of boiling water.
Assortment of rubber corks to fit flasks, test tubes, and a couple of the pickle bottles.
¼ lb. glass tubing in two sizes.
6 ft. rubber tubing in two sizes.
1 package filter paper.
2 books litmus.

CHEMICALS.

1 lb. hydrochloric acid.
1 lb. sulphuric acid.
2 ozs. mercury.
1 lb. marble.
½ lb. chlorate of potassium.
½ lb. manganese dioxide.
1 small bottle metal sodium.
1 pint methylated spirits.
2 ozs. alcohol.

APPENDIX.

TREES AND SHRUBS.

There are special botanical names for all trees and shrubs, just as there are for other plants, such as grasses and weeds. In the following table the scientific or botanical name is put in one column and the common name in the other. In every case two words are used—the first being a noun and the second an adjective; as *picea*, meaning "spruce," and *alba*, meaning "white." In the same way, *quercus* meaning "oak," *quercus alba* is the botanical name of "white oak," and *quercus rubra* "red oak."

Abies balsamifera	Balsam fir.
Acer dasycarpum	Silver maple.
Acer negundo	Ash-leaved or Manitoba maple or box elder.
Acer Pennsylvanicum	Striped maple or moose wood.
Acer rubrum	Red or soft maple.
Acer saccharinum	Sugar or rock maple
Acer spicatum	Mountain maple.
Aesculus hippocastanum	Horse chestnut.
Betula lutea	Yellow birch.
Betula lenta	Black or cherry or sweet birch.
Betula nigra	Red birch.
Betula papyrifera	Canoe or paper birch.
Betula populifolia	White or grey birch.
Carpinus Americana	Hornbeam or blue beech.
Carya alba	Shellbark hickory.
Carya amara	Bitter hickory.
Carya microcarpa	Small fruit hickory.
Carya porcina	Pignut.
Carya tomentosa	White-heart hickory.
Castanea sativa	Chestnut.
Fagus sylvatica	European beech.

Fagus feruginea	American beech.
Fraxinus Americana	White ash.
Fraxinus pubescens	Red ash.
Fraxinus sambucifolia	Black ash.
Gymnocladus Canadensis	Coffee tree.
Juglans cinerea	Butternut.
Juglans nigra	Black walnut.
Juniperus Virginiana	Red cedar.
Larix Americana	Tamarack or American larch.
Liriodendron tulipifera	Tulip tree.
Ostrya Virginica	Ironwood or hop hornbeam.
Picea alba	White spruce.
Picea excelsa	Norway spruce.
Picea nigra	Black spruce.
Pinus Banksiana	Cypress or jack pine.
Pinus mitis	Yellow pine.
Pinus resinosa	Red or Norway pine.
Pinus strobus	White or Weymouth pine.
Platanus occidentalis	Buttonwood or sycamore.
Populus balsamifera	Balsam poplar or Balm of Gilead.
Populus grandidentata	Large toothed aspen.
Populus tremuloides	American aspen or trembling-leaf [poplar.
Quercus alba	White oak.
Quercus coccinea	Scarlet oak.
Quercus prinus	Rock chestnut oak.
Quercus rubra	Red oak.
Quercus stellata	Post oak.
Quercus tinctoria	Quercitron oak.
Quercus macrocarpa	Bur oak.
Salix alba	White willow.
Salix vitellina	Yellow willow.
Sorbus Americana	Mountain ash.
Thuja occidentalis	Arbor-vitæ or white cedar.
Tsuga Canadensis	Hemlock.
Tilia Americana	Basswood or linden
Ulmus Americana	American elm.
Ulmus fulva	Red or slippery elm.
Ulmus racemosa	Cork or rock elm.
Ulmus campestris	European elm.

Table of Weeds

Note 1.—This table presents the common and technical names, with some of the characteristics, of seventy-six weeds which are regarded as the most troublesome in the Province of Manitoba, and in the North West Territories.

Note 2.—By alternate cultivation and smothering crops is meant clean cultivation during the dry season and a heavy seeding of some annual crop, as cow-peas, millet or oats, that will cover the ground thickly and choke down the weeds during the growing season.

Note 3.—Under color and size of flowers the most prominent color and approximate diameter of a single flower, or of a head in the case of composites, are given.

Note 4.—ERADICATION OF ANNUALS.—Begin summer fallowing immediately after harvest, being sure that no weeds go to seed in the fallow. When plowing the fallow next season, harrow in the evening the part plowed during the day, and harrow as often as weeds appear. After the crop is sown pull any weeds which appear in it and burn them. Spring plow and sow all cultivated land not summer fallowed, but give the seeds in the surface soil time to germinate both before and after plowing. Destroy these young weeds before sowing, by cultivating.

No.	Common Names	Technical Names.	Duration	Time of Flowering.	Time of Seeding	Color, Size, and Arrangement of Flowers.	Methods of Eradication.
1	Marsh Cress	Nasturtium palustre	Annual	June to Sept	July to Sept	Yellow, 1-3 in., racemes	
2	Prairie Rocket	Erysimum asperum	do	June & July	July to Aug	do 1-2 to 3-4 in. do	
3	Treacle Mustard	Erysimum parviflorum.	Annual & biennial	do	do	do 1-4 to 1-3 in. do	
4	Hare's Ear Mustard	Erysimum orientale	do	July	August	do 1-4 in. do	
5	Cut-leaved Hedge Mustard	Sisymbrium incisumovar.	do	July & Aug	Aug & Sept	do 1-3 in. do	
6	Grey Mustard	Sisymbrium Hartwegianum.	do	do	do	do 1-3 in. do	
7	Tumbling Mustard	Sisymbrium sinapistrum.	Annual	July	do	Creamy-white, 1-8 in. racemet.	Numbers 1 to 19 should be treated as directed under Note 4.
8	Wild Mustard	Brassica sinapistrum	do	do	do	Yellow, 1-2 in. do	
9	Bird Rape	Brassica campestris	do	do	do	do 1-4 in. do	
10	False Flax	Camelina sativa	do	July to Sept	do	do 1-4 in. do	
11	Ball Mustard	Neslia paniculata	do	do	do	do 1-8 in. do	
12	Shepherd's Purse	Capsella Bursa-pastoris.	Annual or biennial	May to Oct.	June to Oct.	White, 1-16 in. do	
13	Stink Weed, Penny Cress	Thlaspi arvense.	do	April to Oct	do	do 1-8 in. do	
14	Garden Cress	Lepidium sativum	Annual	June	July & Aug	do 1-8 in. do	
15	Pepper Grass	" intermedium	do	June to Sept	Aug & Sept	do 1-16 in. do	

TABLE OF WEEDS—Continued

No.	Common Name.	Technical Name.	Duration.	Time of Flowering.	Time of Seeding.	Color, Size, and Arrangement of Flowers.	Methods of Eradication.
16	Virginian Pepper Grass	Lepidium Virginicum.	Annual ..	Same as No.	15, of which	it is a variety.	
17	Spider Flower..... ...	Cleome integrifolia...	...do....	July & Aug	Aug & Sept	Purple or white, 1-2 in. racemes.	
18	Fumitory Corydalis	Corydalis aurea.....	....do....	.....do.....	September .	Yellow, small clusters, 3-4 in. long.	Nos. 18, 19 and 20, thorough summer fallow.
19	Corn Cockle	Lychnis Githago.....	....do....	July to Sept	.....do.....	Purple, 1 in. solitary.	
20	Cow Herb	Saponaria vaccaria...	....do....	.....do.....	.....do.....	Pink, 3-4 in. cymes.	
21	Sticky Cockle	Silene noctiflora......	....do....	July to Aug	Aug to Sept	White, 1 inch, solitary, opens at night.	Thoro'gh summer fallow.
22	Chickweed	Stellaria media.......	Annual or biennial	Throughout summer.	June to Sep.	White, 1-8 in., in loose clusters.	Thorough cultivation.
23	Purslane...............	Portulaca oleracea ...	....do....	June to Sept	Aug to Sept	Yellow, 1-4 in.. solitary.	Clean cultivation
24	Mallow................	Malva rotundifolia and Malva sylvestri	Perennial.	June to Oct.	July to Oct.	White or purple, single.	Pulling and thorough cultivation.
25	Wild Parsnip..........	Pastinaca sativa.....	Biennial..	July to Oct.	Aug to Oct.	Yellow, 1-4 in., umbel.	Prev't'n of seed'g
26	Carraway	Carum carni.........	....do....	July & Aug	September..	White, in flat clusters, small.	Cutting and Pulling.
27	Canada Flea-bane......	Erigeron Canadensis.	Annual ..	July to Sept	.....do.....	White, 1-4 inch, in heads	Prevent'n of seeding and burning
28	Marsh Elder...........	Iva xanthiifolia	....do....	Aug & Sept	Sept & Oct	Green, 1-4 inch, in heads	........do........
29	Ragweed	Ambrosia trifida	....do....	.....do.....	.....do.....	Yellow, heads forming racemes.	........do........
30	Roman Wormwood....	" artemisiæfolia	....do....	.....do....	.....do.....	Yellow, 1-4 in. in heads.	........do........
31	Cockle Bur............	Xanthium strumarium.	....do....	.....do.....	.....do.....	Green, 1-8 inch in heads.	Prevent'n of seeding and cult'vt'n
32	Sunflower	Helianthus rigidus ...	Perennial.	July to Sept	.....do....	Yellow, 2 to 3 in. do.	........do........
33	Sunflower (Nuttall's)....	" Nuttallii..	....do....	... .do	....do.....	do 2 to 4 in. do.	........do........
34	Yarrow, or Milfoil......	Achillea Millefolium..	....do....	July & Aug	Aug & Sept	White or rose, 1-8 in. do.	........do........
35	Ox-eye Daisy, Marguerite.	Chrysanthemum Leucanthemum	... do....	.....do.....	.....do.....	White, yellow centre, 1 inch in heads.	Prevent'n of seeding, cultivation, and hand pull'g.
36	Wormwood	Artemisia dracunculoides.	....do....	.....do.....	.....do.....	Greenish, 1-16 in., numerous heads, forming panicle.	Prevent'n of seeding, cultivation, and burning.

37	Biennial Wormwood or False Tansy	Artemisia biennis	Biennial	July & Aug.	Aug. & Sept	Greenish, 1-16 in., heads small, in short spikes.	Prevent'n of seeding, cultivation, and burning.
38	Sage Brush	" frigida	....do....	.....do.....	.....do.....	Silvery, 1 1-16 in. round heads, form'g racemes	........do........
39	Canada Thistle	Cnicus arvensis	Perennial.	.....do.....	July to Oct.	Purple, heads 3-4 inch.	Alternate cult'v tn and he'vy crop'g
40	Prairie Thistle	Cnicus undulatus	....do....	June to Sep.	.....do.....	Purple, heads 1 1-2 inch.	........do........
41	Showy Lettuce	Mulgedium pulchellum.	....do....	.....do.....	.....do.....	Blue, heads 3-4 inch.	Prevent'n of seeding and burning
42	Spiny Sowthistle	Sonchus asper	Annual ..	.....do.....	.....do.....	Pale yellow, heads 1-2 in.	........do........
43	Field or Perennial Sow-thistle	" arvensis	Perennial.	.....do.....	.....do.....	Bright yellow, heads 1 to 2 in.	Thoro'gh cult'v'tn and sm'th'g cr'ps
44	Dandelion	Leontodon taraxacum	....do....	May to Oct.	June to Nov.	Yellow heads, 1 in.	Cultivation, spudding.
45	Gumweed	Grindelia squarrosa	Annual ..	Aug & Sept	Sept. & Oct	Bright yel'w, h'ds 3-4 in.	Prevent'n of seeding.
46	Beggars Ticks	Bidens frondosa	....do....	July to Sept	Aug to Oct.	Yellow heads, 1-4 in.	........do........
47	Sea Milkwort	Glaux maritima	Perennial.	July	August	Purplish, bell-shaped, 1-16 in.	........do........
48	Blue Bur	Echinospermum Lappula.	Annual ..	July to Sept	Aug & Sept	Blue, 1-8 in., raceme	Sow clean seed; cultivation.
49	Bindweed	Convolvulus sepium	Perennial.	.....do.....	.....do.....	White, funnel-shaped, 1 1-2 in.	Prevent'n of seeding.
50	Wild Rose	Rosa Blanda	....do....	August	October	Rose	Thorough cultivation.
51	Silverweed	Potentilla anserina	....do....	May to Oct.	June to Oct.	Yellow, 1-2 in. solitary	........do........
52	Evening Primrose	Œnothera biennis	Biennial..	June to Aug	Sept. & Oct	Yellow, in long spikes, 1 to 2 in. across.	Summer fallow and pulling.
53	White-Stemmed Primrose	Œnothera albicaulis	....do....	.....do.....	.....do.....	White, solitary, 1 1-2 in. across	........do........
54	Three-flowered Nightshade	Solanum triflorum	Annual ..	July to Sept	.....do.....	White, 1-2 in., in threes.	Prevent'n of seeding.
55	Nettle	Urtica gracilis	Perennial.	.....do.....	Aug & Sept	Green, 1-12 in., in long panicles.	Mowing in July and Aug., burn'g
56	Wolf Willow, Snowberry	Symphoricarpus occidentalis.	do shrub	Summer	October	Pink, 3-8 in. in clusters.	Plowing up and burning.
57	Dogbane	Apocynum androsæmifolium.	Perennial.	July to Aug	Aug to Sept	Rose color, 3-8 in., in open clusters.	Mowing and cultivation.
58	Greater Plantain	Plantago major	....do....	July to Oct.	Aug to Oct.	White, 1-16 in. spike	Thorough cultivation.

TABLE OF WEEDS—Continued

No.	Common name	Technical Name.	Duration	Time of Flowering	Time of Seeding	Color, Size, and Arrangement of Flowers.	Methods of Eradication.
59	Pigweed	Amaranthus retroflexus.	Annual	July to Oct.	Aug. to Oct	Green, 1-16 in. spike	Thorough cultivation and prevention of seeding.
60	Tumbleweed	Amaranthus albus	do	do	do	Green, 1-16 in. spike	Burning and prevent'n of seed'g
61	Russian Pigweed	Axyris amaranthoides	do	do	do	Green and Yellow, 1-16 in., in pairs.	do
62	Lamb's Quarters	Chenopodium album	do	July to Sept	do	Green and Yellow, 1-16 in., panicle.	do
63	Maple-leaved Goosefoot	" hybridum	do	do	do	do do do	do
64	Oak-leaved Goosefoot	" glaucum	do	do	do	do do do	do
65	(Atriplex) no English name	Atriplex patula (var. hastata).	do	do	do	do do clusters forming long spikes.	do
66	(Kochia) no English name	Koehia scoparia	do., or perennial.	do	do	Green, 1-16 in., clusters	do
67	Russian Thistle	Salsola kali (var. tragus).	do	do	Aug & Sept	Purple, 1-4 in. solitary	Burning and cultivation.
68	Knotgrass, Pigweed	Polygonum aviculare	do	June to Sept	July to Sept	Greenish-white, 1-4 in., clusters.	Cultivation.
69	Wild Buckwheat	" convolvulus	do	do	do	White, 1-4 in., raceme	Burning. Sow clean seed.
70	Spurge	Euphorbia maculata	do	Aug to Sept	Aug & Sept	Reddish, 1-16 in., clusters	Cultivation.
71	Wild Oats	Avena fatua	do	July to Sept	do	Green, 1-4 in., panicle	Burning. Sow clean seed.
72	Barnyard Grass	Panicum crus-galli	do	do	do	Green, 1-8 in., panicle	Prevent'n of seeding.
73	Couch Grass	Agropyrum repens	Perennial.	do	do	Green, 1-8 in., spikes	Cultivation and heavy cropping.
74	Skunk-tail Grass	Hordeum jubatum	Annual	do	Aug to Oct.	do	Prevent'n of seeding,
75	Squirrel-tail Grass	Setaria viridis	do	do	do	do	do
76	Spear Grass	Stipa spartea	do	July	Aug & Sept	Grass, seeds with long awns.	Early mowing

SPRAYING MIXTURES.

The spraying of trees and bushes is done mainly for three purposes: 1, to prevent and destroy the leaf-eating insects; 2, to prevent and destroy sucking insects; 3, to prevent and destroy the germs of plant diseases. Poisons such as Paris Green (which is a compound of arsenic) are used for the first, kerosene (coal oil) emulsion for the second, and copper sulphate for the third. As a rule the first and third are combined.

Bordeaux Mixture.

Copper sulphate (or bluestone)..............	4 pounds.
Lime (fresh).............	4 "
Water	40 gallons.

Place the copper sulphate in a coarse bag and hang it in 5 gallons of water. Slake the lime in 5 gallons of water. Then mix the two and add the other 30 gallons of water. Use only wooden vessels. Paris Green solution is made by stirring up 1 pound of Paris Green in 200 to 300 gallons of water (200 for apple trees, 250 for plums, and 300 for peaches), add about 4 gallons of milk of lime.

When the Paris Green and Bordeaux mixture are to be used together to check the insects and disease at the same time, make the Bordeaux mixture as above stated and add 4 oz. of Paris Green to the 40 gallons of Bordeaux mixture.

Kerosene Emulsion.

Hard soap............ ½ pound, or soft soap,	1 quart.
Boiling water (soft)........................	1 gallon.
Coal oil...............	2 gallons.

After dissolving the soap in the water, add the coal oil and stir well for 5 to 10 minutes. When properly mixed, it will adhere to glass without oiliness. A syringe or pump will aid much in this work. In using, dilute with from 9 to 15 parts of water. Kerosene emulsion may be prepared with sour milk (1 gallon) and coal oil (2 gallons), no soap being required. This latter will not keep long.

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Date Due
